1.0 PURPOSE AND NEED FOR THE LICENSE APPLICANT'S PROPOSED ACTION

1.1 INTRODUCTION

This Environmental Assessment (EA) evaluates the potential environmental effects of this project pursuant to Executive Order (E.O.) 12114 on the Environmental Effects Abroad of Major Federal Actions, whose implementation is guided by the National Environmental Policy Act (NEPA) of 1969, as amended (42 United States Code (U.S.C). § 4321 *et seq*.), and the implementing regulations of the President's Council on Environmental Quality (CEQ; 40 Code of Federal Regulations (CFR) 1500-1508). This document incorporates by reference a prior EA prepared by the Federal Aviation Administration (FAA) dated and referred to as the February 11, 1999 EA, and is included as Appendix A of this document.

The proposed Federal action is to issue a launch operator license (LOL), and a launch-specific license for the Galaxy IIIC mission or other launch-specific licenses should the launch operator license be delayed or not issued, as described in Section 1.2. The purpose of the license applicant's proposed action is to fulfill the mandate of 49 United States Code (U.S.C). Subtitle IX – Commercial Space Transportation, ch. 701, Commercial Space Launch Activities, 49 U.S.C. §§ 70101-70121 and is more fully described in Section 1.3. The need for the license applicant's proposed action is also described more fully in Section 1.3. Section 1.4 presents, briefly, the background of the project, including the Federal government role, prior environmental analyses and documents, and public involvement. That section concludes with a roadmap for the remainder of this EA.

1.2 PROPOSED FEDERAL ACTION

The Federal action is for the FAA, Office of the Associate Administrator for Commercial Space Transportation (AST) to issue an LOL to Sea Launch Limited Partnership (SLLP) that would authorize SLLP to conduct launches from one launch site, within a range of launch parameters, of specific launch vehicles, transporting specified classes of payload. (See 14 CFR. 415.3(b)). The proposed LOL would authorize SLLP to:

- Conduct up to eight launches per year over a five-year period, for a maximum of 40 launches;[a]

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[a] Even under an LOL, a license applicant must provide the FAA with launch specific information. This will permit the FAA to have continuing oversight over SLLP operations. See 14 CFR 415.73 Continuing Acceptance of License Applications; Application for Modification of License. In accordance with 14 CFR 415.79, not later than 60 days before each flight conducted under a launch operator license, a licensee shall provide the FAA the following launch specific information:
1. payload information contained in 14 CFR 415.59;
2. flight information, including launch vehicle, planned flight path, including staging and impact locations, and on-orbit activity of the launch vehicle including payload delivery point(s); and
3. mission specific launch waivers, approved or pending, from a federal launch range from which the launch will take place, that are unique to the launch and may affect public safety.

Not later than noon, eastern standard time (EST), 15 days before each licensed flight a licensee shall submit to the FAA a completed Federal Aviation Administration/U.S. Space Command (FAA/USSPACECOM) Launch Notification Form (Office of Management and Budget (OMB) No. 2120-0608).

- Use a launch site at 0° latitude and 154° W longitude;
- Launch along a range of azimuths from 82.6° to 97.4°, inclusive[b];
- Use a Zenit-3SL launch vehicle; and
- Transport specified classes of payloads.

Any change to these LOL parameters would require additional environmental and safety analyses.

The FAA is also evaluating the possibility of issuing a launch-specific license to SLLP for the launch of Galaxy IIIC, as well as other potential launch-specific licenses (not to exceed eight per year) as necessary should the proposed LOL not be issued or be delayed. The proposed launch-specific licenses would authorize the SLLP to conduct specific launches:

- From a launch site at 0° latitude and 154°W longitude;
- On a launch azimuth within a range from 82.6° to 97.4°, inclusive;
- Using a Zenit-3SL launch vehicle; and
- Transporting specified classes of payloads.

The launch site location, launch vehicles, and classes of payloads that would be authorized under the proposed launch-specific licenses would be identical to the launch site location, launch vehicles, and classes of payloads that would be authorized under the proposed LOL. In addition, the launch azimuths that would be authorized under the launch-specific licenses would fall within the launch azimuth range that would be authorized under the LOL. Finally, the number of launch-specific licenses that would be issued per year would not exceed the number of the launches that would be authorized annually under the LOL (i.e., eight per year). The conduct that would be authorized under the proposed LOL and launch-specific licenses is identical, only the license application process would differ. Therefore, discussions and analyses of potential environmental impacts of the LOL and the launch-specific licenses are addressed together. Throughout the document, when the license applicant's proposed action is discussed, while emphasis is placed on the launch operator license, it should be understood that the launch-specific licenses are included in the license applicant's proposed action.

To obtain a launch license (either launch-specific or a launch operator license), an applicant must obtain policy and safety approvals from the FAA. Requirements for obtaining these approvals are contained in 14 CFR 415 Subpart B (Policy Review and Approval), Subpart C (Safety Review and Approval for Launch From a Federal Launch Range, including the calculation of acceptable flight risk), and Subpart F (Safety Review and Approval for Launch From a Launch Site not Operated by a Federal Launch Range). Other requirements include payload determination (14 CFR 415 Subpart D), financial responsibility (14 CFR 415.83, Subpart E) and environmental review (14 CFR 415 Subpart G).

A launch licensee shall report a launch accident, launch incident, or a mishap that involves a fatality or serious injury (as defined in 49 CFR 830.2) immediately to the FAA Washington Operations Center and provide a written preliminary report in the event of a launch accident or launch incident, in accordance with the accident investigation plan (AIP) submitted as part of its license application under 14 CFR 415.41.

[b] Within this range of azimuths, launches on azimuths of 83.28° to 84.50° have Impact Limit Lines (ILL) that overlay Cocos Island, 85.07° to 86.36° have ILL that overlay Malpelo Island, and 86.80° to 92.89° have ILL that overlay the Galapagos Island group. ILL are defined as the debris dispersion area where, with a statistical confidence of 99.67%, all the stages from successful flight as well as any material from a failure would impact. See Sections 2.3.4 and 2.3.5 below.

1.3 PURPOSE AND NEED FOR THE LICENSE APPLICANT'S PROPOSED ACTION

Access to space has become increasingly important for the deployment of satellites used for scientific research, communications, and multimodal transport navigation systems. Given the infrastructure and technology development costs associated with launching and deploying satellites, the Federal Government has been responsible for the majority of launches. However, with the increasing demand for access to space, especially for communications satellites, commercial launch companies have begun to offer launch services to meet this demand.

The purpose of the license applicant's proposed action as defined in 49 U.S.C. Subtitle IX – Commercial Space Transportation, ch. 701, Commercial Space Launch Activities, 49 U.S.C. §§ 70101-70121 is to:

- Promote economic growth and entrepreneurial activity through use of the space environment for peaceful purposes;
- Encourage the U.S. private sector to provide launch vehicles, reentry vehicles, and associated services by simplifying and expediting the issuance of licenses;
- Provide FAA oversight and coordination of licensed launches and to protect the public health and safety, safety of property, and national security and foreign policy interests of the U.S.; and
- Facilitate the strengthening and expansion of the U.S. space transportation infrastructure.

The need for the license applicant's proposed action is to streamline the FAA's licensing process while still assuring public safety and proper environmental review. Such a streamlined process will promote the entrepreneurial activity of a licensed launch provider. The proposed LOL would cover multiple launches using the same infrastructure at the same launch location through a range of launch azimuths without the need to re-evaluate license applications for individual launches unless there are changes in the license applicant's proposed action, environmental impacts or conditions of approval. The proposed LOL would allow SLLP to conduct up to eight launches per year for five years, for a maximum of 40 launches. The proposed LOL would allow SLLP to launch on exact equatorial azimuths (e.g., 90^{o}), which are optimal for geosynchronous orbit (GSO) launches in terms of fuel efficiency, payload weight, and satellite life span.

1.4 BACKGROUND

1.4.1 Federal Government Role

The purpose of 49 U.S.C. Subtitle IX – Commercial Space Transportation, ch. 701, Commercial Space Launch Activities, 49 U.S.C. §§ 70101-70121 is to promote, encourage, and facilitate the growth of the U.S. commercial space transportation industry. The U.S. Department of Transportation (DOT) was designated as the lead agency for licensing and regulating all U.S. commercial launch operations to ensure that they are conducted safely and responsibly. In November 1995, these responsibilities were delegated from the Office of the Secretary of Transportation to the FAA.

1.4.2 Prior Environmental Analyses

The FAA previously analyzed the environmental effects of licensed launch operations and launches in the Programmatic Environmental Assessment of Commercial Expendable Launch Vehicle Programs (February 1986).

The Final Environmental Assessment for the SLLP Program dated February 11, 1999 (February 11, 1999 EA), described proposed launches and alternatives, the affected environment, potential environmental impacts, and environmental mitigation measures for the launches of one demonstration payload and one commercial satellite in the first year of operation, and six per year thereafter along a single launch azimuth. It included an Environmental Finding, which concluded that licensing the proposed launches was not a major Federal action that would significantly affect the quality of the human environment, and that preparation of an Environmental Impact Statement (EIS) was not required (see Appendix C). The FAA also prepared additional documents, including Written Reevaluations (WR) and findings, for two individual launches with azimuths that differed from that evaluated in the February 11, 1999 EA and for the use of UDMH and nitrogen tetroxide (N_2O_4) in the Upper Stage for Mission 6R (see Appendix D).

1.4.3 History of the License Applicant's Proposed Project

The SLLP project is an international commercial space launch project owned and operated jointly by Boeing Commercial Space Company of the United States, RSC Energia of Russia, KB Yuzhonoye and PO Yuzhmash of Ukraine, and Moss Maritime a.s. of Norway. The project's main assets are a seagoing mobile launch platform (LP), assembly and command ship (ACS), Home Port facilities in Long Beach, California, and the Zenit-3SL. The project is intended to place payloads in orbit from a launch site in the east central Pacific Ocean at 0° latitude and 154° W longitude.

On March 27, 1999, SLLP successfully completed its first demonstration payload launch (referred to as Mission 1), that confirmed the design and operation of the complete SLLP system. On October 9, 1999, commercial operations of SLLP officially began with the launch of DIRECTV 1-R, a direct broadcast satellite (Mission 2). Mission 3, for an ICO communication satellite, involved a nonequatorial launch azimuth (i.e., 135°) that was not evaluated in the February 11, 1999 EA. Therefore, a WR of the potential environmental effects of the launch along this azimuth was prepared for Mission 3 (see Appendix D). The WR findings were used by FAA in issuing a license for this mission. On March 12, 2000, SLLP launched the ICO communications satellite. Because of a malfunctioning propulsion valve, however, the flight was terminated before reaching orbit—approximately eight minutes after liftoff—by automatic on-board safety systems. On July 28, 2000, again using an equatorial launch azimuth as evaluated in the February 11, 1999 EA, SLLP successfully sent into orbit a PanAm Sat communications satellite (Mission 4). On October 21, 2000, SLLP successfully sent into orbit Thuraya-1, a mobile communications satellite (Mission 5). Because Mission 5 also involved an azimuth not evaluated in the February 11, 1999 EA (i.e., 83.28° rather than 88.67°), a WR was prepared to determine whether the license applicant's proposed action conformed to the plans and projects analyzed in the earlier EA; whether the data and analyses in the earlier EA were still valid; and whether all pertinent conditions and requirements of the prior approval were or would be met in the new action. The first attempted launch of XM-1, a radio communications satellite ended in a launch abort (Mission 6). This launch was successfully carried out on May 8, 2001 (Mission 6R). A WR was prepared for Mission 6R which addressed the impact of using 7 to 13 gallons of unsymmetrical dimethylhydrazine (UDMH) fuel along with N_2O_4 oxidizer, imported from Russia as the propellants for the Upper Stage (see Appendix E). On March 18, 2001, using an equatorial launch azimuth as evaluated in the February 11, 1999 EA, SLLP successfully sent into orbit XM-2, a radio communications satellite (Mission 7).

1.4.4 Relationship Between this EA and the February 11, 1999 EA

This document incorporates by reference the February 11, 1999 EA. The February 11, 1999 EA considered the license applicant's proposed action of issuing launch licenses for two SLLP launches, a demonstration launch carrying a simulated payload and a launch to deploy a satellite, and also considered the potential environmental impacts of up to six launches per year along the 88.67° azimuth. The environmental impacts of specific launch licenses issued for launches along this azimuth were analyzed in the February 11, 1999 EA.

The license applicant's proposed action in this EA would use the Home Port facilities; conduct the same pre-launch operations; use the same launch vehicle and launch site (0° latitude and 154°W longitude); and would conduct the same post-launch operations as evaluated in the February 11, 1999 EA. These aspects of the license applicant's proposed action are the same as those addressed in the February 11, 1999 EA. This EA incorporates by reference the February 11, 1999 EA, which is accessible at the FAA web site (http://ast.faa.gov) and is included as Appendix A of this document. This EA focuses on potential impacts of the license applicant's proposed action and the cumulative impacts of the launches that could occur as a result of issuing an LOL.

1.4.5 Public Involvement

The FAA issued a proposed Environmental Finding Document, finding no significant impact for the draft version of the February 11, 1999 EA, which was made available for public review from April 23 to May 26, 1998. The FAA also met with representatives of the Governments of Ecuador, Kiribati, Australia, and New Zealand, and with representatives of the South Pacific Regional Environmental Programme (SPREP). Additional meetings with representatives of SPREP and the Government of Ecuador have been held periodically to discuss upcoming launches and longer-term plans, such as the application for an LOL. A draft of this EA was offered for public comment and announced in the U.S. *Federal Register*.

1.4.6 Roadmap for this EA

This EA is structured as follows:

- Introduction and description of the purpose and need for the license applicant's proposed action (Section 1.0).
- Description of the license applicant's proposed action and other alternatives, including No Action (Section 2.0).
- Description of the environment that could be affected by the license applicant's proposed action (Section 3.0).
- Evaluation of the environmental effects associated with the license applicant's proposed action and reasonable alternatives, including No Action (Section 4.0).

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2.0 DESCRIPTION OF LICENSE APPLICANT'S PROPOSED ACTION AND ALTERNATIVES

2.1 SCREENING CRITERIA

For this EA, the FAA considered screening criteria to evaluate the license applicant's proposed action and reasonable alternatives to that action. The screening criteria are based on the purposes established in 49 U.S.C. Subtitle IX – Commercial Space Transportation, ch. 701, Commercial Space Launch Activities, 49 U.S.C.§70101-70121, as follows:

- To promote economic growth and entrepreneurial activity through use of the space environment for peaceful purposes.

- To encourage the United States private sector to provide launch vehicles, reentry vehicles, and associated services by simplifying and expediting the issuance and transfer of commercial licenses; and facilitating and encouraging the use of Government-developed space technology.

- To provide FAA oversight and coordination of commercial launch activities and to protect the public health and safety, safety of property, and national security and foreign policy interests of the United States.

- To facilitate the strengthening and expansion of the United States space transportation infrastructure, including the enhancement of United States launch sites and launch-site support facilities, and development of reentry sites, with Government, State, and private sector involvement, to support the full range of United States space-related activities.

These criteria are applied in Section 2.6 to evaluate the reasonableness of the license applicant's proposed action and potential alternatives.

2.2 LICENSE APPLICANT'S PROPOSED ACTION

The license applicant's proposed action would be for the FAA to issue a launch operator license (LOL) to SLLP. The proposed license would authorize SLLP to:

- Conduct up to eight launches per year over a five-year period, for a maximum of 40 launches;
- Use a launch site at 0° latitude and 154° W longitude;
- Launch along a range of azimuths from 82.6° to 97.4°, inclusive[a];
- Use a Zenit-3SL launch vehicle; and
- Transport specified classes of payloads.

Any change to these proposed LOL parameters would require additional environmental and safety analyses.

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[a] Within this range of azimuths, launches on azimuths of 83.28° to 84.50° have Impact Limit Lines (ILL) that overlay Cocos Island, 85.07° to 86.36° have ILL that overlay Malpelo Island, and 86.80° to 92.89° have ILL that overlay the Galapagos Island group. Impact Limit Lines are defined as the debris dispersion envelope where, with a statistical confidence of 99.67%, all the stages from successful flight as well as any material from a failure would impact. See Sections 2.3.4 and 2.3.5 below.

The license applicant's proposed action would also include having the FAA issue a launch-specific license to SLLP for the launch of Galaxy IIIC, as well as other potential launch-specific licenses (not to exceed eight per year) as necessary should the proposed launch operator license not be issued or be delayed. The proposed launch-specific licenses would authorize the SLLP to conduct specific launches:

- From a launch site at 0° latitude and 154° W longitude;
- On a launch azimuth within a range from 82.6° to 97.4°, inclusive;
- Using a Zenit-3SL launch vehicle; and
- To transport specified classes of payloads.

The launch site location, launch vehicles, and classes of payloads that would be authorized under the proposed launch-specific licenses would be identical to the launch site location, launch vehicles, and classes of payloads that would be authorized under the proposed LOL. In addition, the launch azimuths that would be authorized under the launch-specific licenses would fall within the launch azimuth range that would be authorized under the LOL. Finally, the number of launch-specific licenses that would be issued per year would not exceed the number of the launches that would be authorized under the LOL per year (i.e., eight per year). The conduct that would be authorized under the LOL and launch-specific licenses is identical, only the license application process would differ. Therefore, discussions and analyses of potential environmental impacts of the proposed LOL and launch-specific licenses are addressed together. Thus, throughout the document, when the license applicant's proposed action is discussed, while emphasis is placed on the launch operator license, it is understood that the launch-specific licenses are included in the license applicant's proposed action.

The present Zenit-3SL configuration uses Russian-produced kerosene and liquid oxygen (LOX) for the propulsion of Stages I and II and the Upper Stage or Block DM-SL. Attitude control systems of the Upper Stage currently use a propulsion system of monomethylhydrazine (MMH) and nitrogen tetroxide (N_2O_4). Other propellants that may be used during the five-year period covered by the LOL are also considered in the license applicant's proposed action. Specifically, unsymmetrical dimethylhydrazine (UDMH) is considered as a potential substitute for MMH in the Upper Stage attitude control system. The environmental consequences of this substitution are discussed in Section 4.1.1.3 (Sections 4.2.1.3 and 4.3.1.3 for alternatives) and Appendix E of this EA. UDMH and MMH are both hydrazine fuels (a type of launch vehicle and spacecraft fuel used in hypergolic propellant systems) that have different chemical and physical parameters (e.g., boiling point, specific gravity, vapor pressure, and flash point). The two fuels, however, are similar in terms of their reactivity, products of combustion (based on N_2O_4 as an oxidizer), exposure limits, and United Nations (UN) and United States Department of Transportation (DOT) hazard classification. The environmental consequences from the use of UDMH specific to the Upper Stage would be similar to those of MMH.

In addition, U.S.-produced kerosene or the Russian-produced kerosene substitute Boktan may be used instead of the Russian-produced kerosene for propulsion. Section 4.1.1.3. (Sections 4.2.1.3 and 4.3.1.3 for alternatives) and Appendix E of this EA compare these products. A full operational evaluation of Boktan has not yet been completed, but preliminary analysis indicates that physical and safety parameters of the three products are similar and the environmental consequences from the use of Boktan would be similar to those of both U.S. and Russian produced kerosene. Should SLLP decide to use Boktan at some point in the future, proper environmental analysis will be conducted as appropriate.

The commercial satellites to be launched—for telecommunication, observational, navigational, and scientific purposes—are propelled by systems employing hydrazine, MMH, N_2O_4, xenon ion propulsion, and/or electrical propulsion. Satellite systems are provided to SLLP fully contained (i.e., assembled, fueled and containerized) by the manufacturer.

Under the license applicant's proposed action and the other alternatives analyzed in this EA, each launch would involve maintenance and preparation of equipment at the Home Port in California, transit of the ACS and LP (with the launch vehicle onboard) to 0° latitude (on the Equator) and 154° W longitude, pre-launch preparations, launch and flight, and post-launch operations and monitoring. These procedures are briefly described in Sections 2.2.1 through 2.2.5.

2.2.1 Home Port

The Home Port is located on the former Long Beach Naval Station in Long Beach, California. The Home Port provides the facilities, equipment, supplies, personnel, and procedures necessary to receive, transport, process, test, and integrate the satellite payload and its associated support equipment with the launch system. It also serves as the home base for launch operations.

The three launch vehicle stages, the payload fairing, and the payload adapter are transported to the Home Port where they are processed, integrated with the spacecraft (forming the Integrated Launch Vehicle or ILV), and prepared for ocean transport. The ILV, personnel, and propellants (including kerosene and LOX) are transported onboard the LP and the ACS to the launch location. During transport to the launch site, the ILV electrical systems are checked and charged, and launch command processes and contingency measures are rehearsed.

The design, permitting, construction, and operation of the Home Port was evaluated in the February 11, 1999 EA (which addressed up to six launches per year, after the initial two launches). In preparing this EA, a verification of Home Port operations was conducted and several differences related to design, permitting and operation have been identified. This new information has been included in this document as Appendix B and updates the information in Appendices A and B of the February 11, 1999 EA, which is included in its entirety as Appendix A of this document.

The use of UDMH will not create new impacts from Home Port operations as SLLP will modify and comply with all Federal, State, and local permit requirements prior to UDMH arrival on-site. In addition, scrubber filters have been installed at the Home Port to prevent release of UDMH vapors.

The following documents need to be amended prior to UDMH arrival on-site at Home Port:

1. Hazardous Material Inventory Emergency Planning and Community Right to Know Act (EPCRA), Long Beach Department of Health, Certified Unified Program Agencies (CUPA)
2. Business Emergency Plan, Long Beach Fire Department
3. Operations Manual for the Transfer of Hazardous Material in Bulk, U.S. Coast Guard (USCG)
4. Integrated Contingency Plan, Environmental Protection Agency (EPA), Occupational Safety and Health Administration (OSHA), California OSHA
5. California Offshore Emergency Service (COES), USCG

The following document will need to reflect the change in 2002:

1. Annual Emissions Inventory (Year 2001), South Coast Air Quality Management District (SCAQMD)

The following document will not require changes because thresholds are not exceeded:

1. Risk Management Plan, Long Beach Department of Health (CUPA)

Scrubber filter elements have been specifically designed, constructed, and delivered to SLLP to capture and neutralize vapors from UDMH. Following approval of the use of UDMH, these scrubbers will be installed at the SLLP facilities.

Substituting Russian Grade N_2O_4 for U.S. Grade N_2O_4 will not affect Home Port operations or permitting.

2.2.2 Pre-Launch

In the hours prior to launch, the LP is ballasted to a more stable, semi-submerged position. Pre-launch operations would involve only the final equipment and process checks, the coupling of fuel lines to the ILV prior to fueling, the transfer of kerosene and LOX fuels, and the decoupling of the fueling apparatus. All employees would be removed from the LP. The process would be remotely controlled from the ACS, located on the safety perimeter five kilometer (km) (three miles (mi)) away. Pre-launch operations are the same under the license applicant's proposed action as those described in the February 11, 1999 EA, Section 4.3.1.

2.2.3 Launch and Flight

Once the pre-launch preparations are complete, the launch and flight phase of the mission begins. The launch vehicle (the Zenit-3SL) uses kerosene and LOX as primary propellants. Prior launches have used Russian-produced kerosene for propulsion. U.S.-produced kerosene as well as a Russian-produced kerosene substitute called Boktan are being evaluated for future use. Testing will be conducted and if found suitable, these propellants may be used in future missions. Available data on Boktan, and U.S.-produced and Russian-produced kerosene are provided in Appendix E of this EA.

First-stage flight of the mission begins in international waters at 0° latitude and 154°W longitude and transits eastward over the equatorial Pacific Ocean. Stage and fairing separations occur as described in Table 2-1 and shown in Figure 2-1. The areas of stage and fairing deposition are outside the area included in the *Convention for the Protection for the Natural Resources and Environment of the South Pacific Region.* (See Section 4.1.1.2 of this EA for more detail.)

TABLE 2-1: IMPACT ZONES FOR STAGES AND FAIRING

Flight Element	Latitude (degrees)	Longitude (degrees)
Stage I	2 S to 2 N	147.7 W to 145.5 W
Fairing halves	2.2 S to 2.2 N	146.6 W to 142.2 W
Stage II	6 S to 6 N	116.6 W to 105.1 W

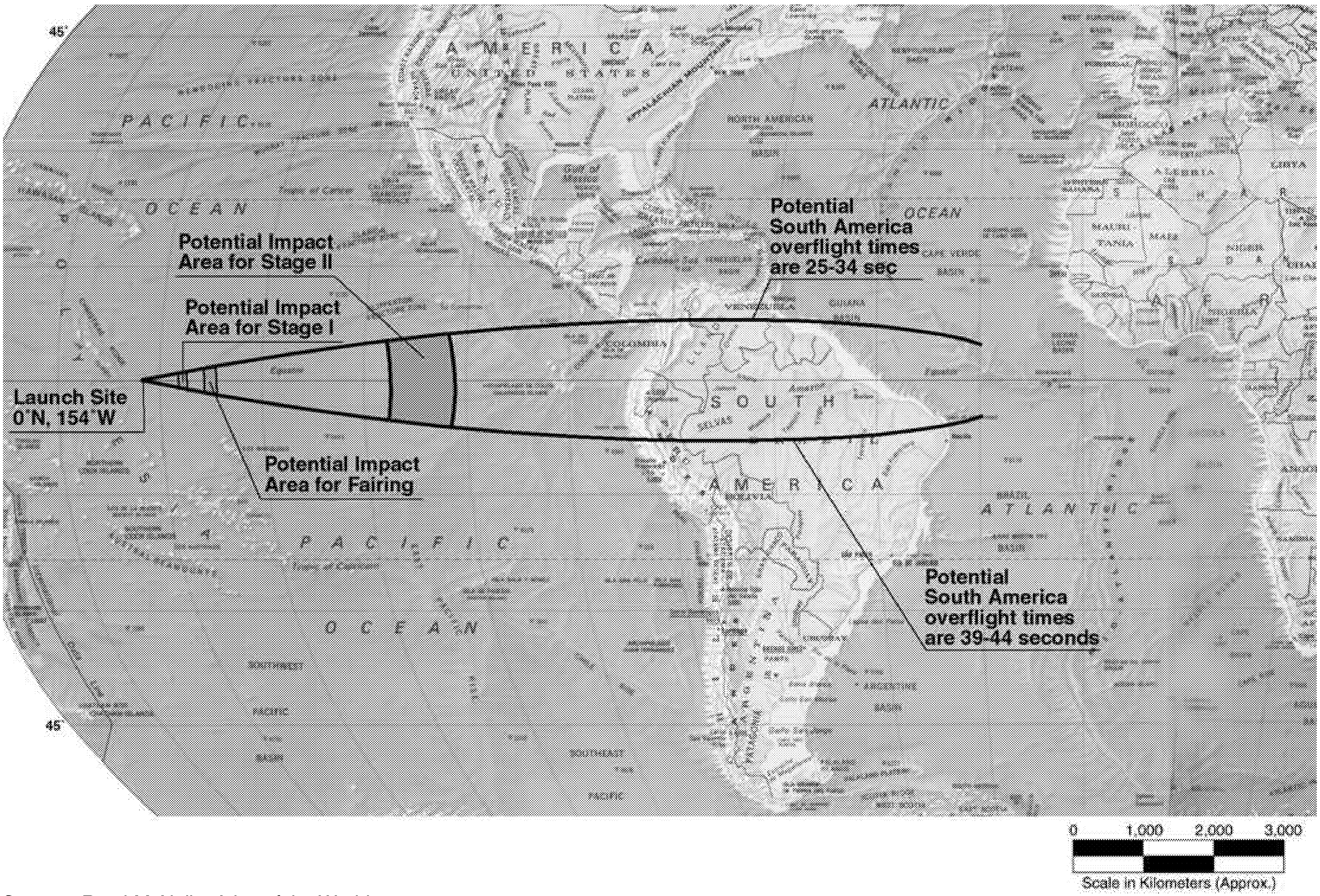
Based on the launch industry's experience with composite fairings, the two halves of the SLLP fairing would break up during descent and upon impact with the ocean surface. Prior SLLP launches have used a payload fairing with a 4.2 meter (m) (13.9 feet (ft)) diameter. This EA addresses the use of a larger fairing, up to 5.0 m (16.5 ft) in diameter, which would allow for maximum payload size and weight (Figure 2-1 and Table 2-1 are based on the 5.0 m fairing). Should SLLP propose to use a fairing larger than 5.0 m at some point in the future, proper environmental analysis will be conducted as appropriate. Under normal operating and contingency conditions, impacts from the stages and fairing would occur well outside the 200-nautical mile Exclusive Economic Zones (EEZs) of all countries in the area.

The Upper Stage begins powered flight over international waters and propels the satellite payload toward South America. Transit time across South America would range from 25 to 44 seconds (sec), depending on the azimuth of the launch. Once orbital, the Upper Stage separates from the payload, reorients, and executes an approximately 300 second burn to ensure that the Upper Stage does not affect the payload; this maneuver also provides for a safe storage orbit. MMH and N_2O_4 were used in all missions except 6R, which used UDMH and N_2O_4. Other materials may be used in the future after operational evaluation. Data on UDMH are provided in Appendix E of this EA.

The payload is moved and oriented into final position by its own propulsion system. The payloads use primarily hydrazine, MMH, UDMH, and N_2O_4 for propulsion. Other systems that may be used for propulsion, after evaluation and approval by FAA include xenon ion propulsion and electrical propulsion.

The release of any emissions from these later on-orbit maneuvers would occur well above the stratosphere and would not pose any significant environmental effects. Similarly, destruction of these propellants during a failure would be complete and incidental to the failure event.

Figure 2-1
Launch Operator License Groundtrack Corridor
(for 82.6 to 97.4 Launch Azimuths)



Source: Rand McNally, Atlas of the World.

Table 2-2 summarizes potential mission characteristics.

TABLE 2-2: POTENTIAL MISSION SUMMARY CHARACTERISTICS

Mission Element	*Characteristic*
Payload	Commercial satellite
Launch vehicle	Zenit-3SL
Launch site	0° latitude, 154° W longitude
Launch azimuth	82.6°to 97.4°, inclusive
Stages I, II, fairing impact zones	Deep and open ocean, limited vessel traffic, low biological productivity; *see Table 2-1 and Figure 2-1*
Overflight zone	Islands in eastern Pacific, including Galapagos Islands, Cocos Island, and Malpelo Island; portions of South and Central America

2.2.4 Post-Launch

After the launch, crews reoccupy the LP. In preparation for transit back to the Home Port, the crews collect any debris for examination, and subsequently wash and repaint the deck of the LP. The post-launch operations associated with the license applicant's proposed action are the same as that described in Section 4.3.3 of the February 11, 1999 EA. Debris would be disposed of in accordance with the International Convention for the Prevention of Pollution (in compliance with MARPOL 73/78) or brought back to Home Port for proper disposal. Monitoring activities are also conducted post-launch in compliance with the Environmental Monitoring and Protection Plan discussed in detail in Section 4.6.

2.2.5 Failure Scenarios

There are several possible failed mission scenarios considered in this EA:

- Explosion on the LP (impacts are discussed in Sections 4.1.2.1, 4.2.2.1, and 4.3.2.1 of this EA);
- In-flight failures of Stage I or Stage II (resulting from either an explosion or thrust termination) over the open ocean, (impacts are discussed in Sections 4.1.2.2, 4.2.2.2, and 4.3.2.2);
- In-flight failures of the Upper Stage (resulting from either an explosion or thrust termination) over the open ocean, Oceanic Islands, or South America (impacts are discussed in Sections 4.1.2.3, 4.2.2.3, and 4.3.2.3); and
- The cumulative failure of a number of launches in a single year along the same azimuth or azimuths in close proximity to one another (impacts are discussed in Sections 4.1.4.6, 4.2.4.6, and 4.3.4.6).

The failure scenarios, including multiple failures affecting the same area, generally involve the loss and return to Earth of some or virtually all of the ILV's components and hazardous materials.

This EA also addresses the scenario, in which the pre-launch process is interrupted moments before launch, resulting in a postponed or aborted launch. In this case, either the countdown is re-started, perhaps one to four days later, and the ILV is launched, or the ILV is stowed in the LP hanger, and the LP and ACS return to Home Port. While this scenario is not technically a failure, it is appropriate to consider possible effects to the environment from such an occurrence.

2.3 ALTERNATIVES CONSIDERED

This section discusses the alternatives to the license applicant's proposed action considered by the FAA and identifies reasonable alternatives considered in detail using the screening criteria described above in Section 2.1. For each alternative, unless otherwise stated, the Home Port, pre-launch, launch and flight, post launch, and possible failure scenarios will be the same as those described in Sections 2.2.1, 2.2.2, 2.2.3, 2.2.4, and 2.2.5, respectively. Alternatives that were previously considered in the February 11, 1999 EA, Section 2.2, are described in Section 2.4 of this EA.

Five alternatives to the license applicant's proposed action are identified for consideration in this EA. Each alternative still entails the proposed issuance of an LOL to SLLP (with the exception of the No Action Alternative). To this end, all aspects of each alternative (e.g., ILV and propellants) remain the same as the license applicant's proposed action except as specifically identified below.

2.3.1 Alternative Allowing up to 12 Launches Per Year

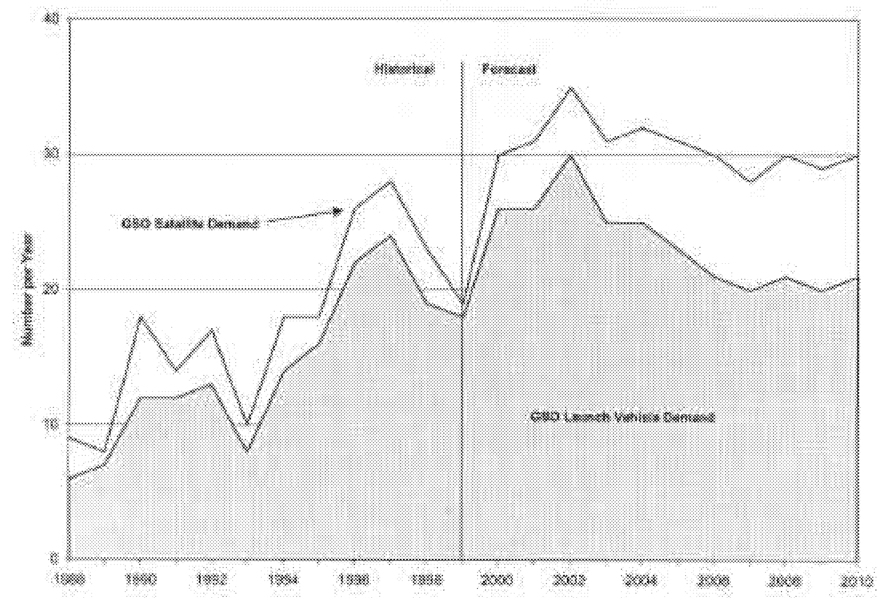
This alternative would involve the proposed issuance of an LOL to SLLP that would allow up to 12 launches per year as opposed to up to eight launches per year in the license applicant's proposed action.

The FAA and the Commercial Space Transportation Advisory Committee (COMSTAC) routinely evaluate the general market for satellite and launch demand. Figure 2-2 shows past launch data and the FAA's current projection of future demand for geosynchronous orbit (GSO) satellite launch services. As SLLP's launch system is particularly suited for launching heavy satellites, SLLP has identified GSO satellites to be the primary driver of its commercial operations.

As Figure 2-2 indicates, GSO launch vehicle demand is projected to range from 20 to 30 launches per year over the next decade. The FAA's market forecast for non-geostationary orbits (e.g., low-earth orbit (LEO), medium-earth orbit (MEO)) shows a major decline of proposed systems to be launched in non-geostationary orbits—a projected reduction of almost 40 percent (COMSTAC, 2000). Therefore, the FAA forecasts that most launches in the near future will be for GSO satellites.

SLLP has indicated that 12 launches per year was the most launches that it could reasonably be expected to conduct, based on operational considerations to date. All other aspects of this alternative (e.g., ILV and propellants) would remain the same as the license applicant's proposed action.

FIGURE 2-2: HISTORICAL AND FORECASTED DEMAND FOR GSO LAUNCHES



Source*: 2000 Commercial Space Transportation Forecasts*, Federal Aviation Administration's Associate Administrator for Commercial Space Transportation and the COMSTAC, May 2000.

2.3.2 Alternative with a Range of Azimuths Between 70° and 110°

This alternative would entail the proposed issuance of an LOL to SLLP with an increased range of azimuths from the 82.6° to 97.4° in the license applicant's proposed action to the 70° to 110°. All other aspects of this alternative (e.g., ILV and propellants) would remain the same as the license applicant's proposed action.

The range of possible azimuths is between 0° and 360° (i.e., the ILV theoretically could be launched in any direction from the launch site). Launches with azimuths between 180° and 360° would generally be going west or counter to the Earth's rotation and would therefore not be practical. Inclined azimuths (defined herein as 0° to 70° and 110° to 180°) would require extensive maneuvers of heavier satellites to move them into their final geosynchronous orbit. This would result in an increased transit time and fuel use, and pose an additional risk of failure or anomalies due to the required multiple firings of the Upper Stage to reach proper orbit. The increased risk of failures would likely cause orbital debris, which is hazardous to other spacecraft. Therefore, these azimuths are generally riskier, and are not considered feasible for GSO. Thus, only azimuths between 70 ° to 110° are a potentially feasible range of azimuths for GSO.

2.3.3 Alternative with Avoidance of National Parks and National Reserves

This alternative would involve the proposed issuance of an LOL to SLLP for the range of azimuths between 82.6° to 97.4°, but would require avoidance of specific azimuths within this range that would overfly any Nation's national parks or national reserves. There are 31 national parks or national reserves—five of which are on the UNESCO World Heritage Site List (Hammond, 1996; UNESCO, 2001) that could be potentially affected by launches in the proposed range of azimuths. The following azimuths would not require a direct launch vehicle overflight of a national park or a national reserve:

- 85.50° to 85.67°
- 92.90° to 93.25°
- 93.83° to 94.75°
- 96.68° to 97.40°

If ILL were considered, no azimuth in the range of 82.6° to 97.4° would be permissible under this alternative. All other aspects of this alternative (e.g., ILV and propellants) would remain the same as the license applicant's proposed action.

2.3.4 Alternative with Avoidance of the Oceanic Islands

This alternative would involve the proposed issuance of an LOL to SLLP for the same range of azimuths as the license applicant's proposed action (i.e., 82.6° to 97.4°), but would require avoidance of any azimuths that overfly any of the Oceanic Islands (i.e., Galapagos Islands, including the 40-mile marine sanctuary extending from all islands; Cocos Island; and Malpelo Island). The following azimuths would (see Figure 2-3) not involve overflight of any of the Oceanic Islands (including the ILL debris dispersion overlay)[b]:

- 82.60° to 83.28°
- 84.50° to 85.07°
- 86.36° to 86.80°
- 92.89° to 97.40°

Consequently, launches along azimuths ranging from 83.28° to 84.50°, 85.07° to 86.36°, and 86.80° to 92.89° would not be allowed under this alternative. All other aspects of this alternative (e.g., ILV and propellants) would remain the same as the license applicant's proposed action.

2.3.5 Alternative with Avoidance of the Galapagos Islands

This alternative would involve the proposed issuance of an LOL to SLLP for the same range of azimuths as the license applicant's proposed action (i.e., 82.6° to 97.4°), but would require avoidance of any azimuths that overfly the Galapagos Island group (including the 40-mile marine sanctuary extending from all islands). The following azimuths would (see Figure 2-4) not involve overflight of any of the Galapagos Islands (accounting for the ILL overlay)[Ibid.]:

- 82.60° to 86.80°
- 92.89° to 97.40°

Consequently, launch azimuths ranging from 86.80° to 92.89° would not be allowed under this alternative. All other aspects of this alternative (e.g., ILV and propellants) would remain the same as the license applicant's proposed action.

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[b] It should be noted that ILLs associated with an azimuth of 88.67°, in fact, would overlay Wolf and Darwin Islands of the Galapagos Island group. This azimuth was fully evaluated in the February 11, 1999 EA, and subsequent Environmental Finding and has been included in SLLP launch-specific licenses.
Ibid.

2.4 PREVIOUSLY CONSIDERED ALTERNATIVES

The alternatives discussed below were considered in the February 11, 1999 EA, Section 2.2, and were eliminated from further consideration and analysis at that time.

2.4.1 Alternative Launch Vehicle

Two launch vehicles, the Zenit and the Cyclone, were available and considered viable candidates at the time the SLLP project was initiated (see Section 2.2.1 of the February 11, 1999 EA). During that consideration, the Cyclone's payload capacity was determined to be too small to handle projected customer demand. In addition, the Zenit launch vehicle system allows for horizontal integration, processing, and transport of the launch vehicle stages and payload, while the Cyclone launch vehicle does not. This feature was deemed essential for an ocean-based launch location because it would allow the ILV to remain in a safe and stable horizontal position during transport.

In addition to cost, efficiency, and market advantages, the Zenit and Upper Stage operating systems, staffing requirements, and propellant characteristics were considered favorable in terms of possible risk to SLLP operating personnel and the environment. Designing and producing a new launch vehicle, or procuring alternative assets from other launch system providers, were not considered commercially viable options. Furthermore, the integration of these alternative launch vehicles with other SLLP launch infrastructure had not been tested or proven safe and reliable.

Therefore, only the Zenit and Upper Stage satisfied all payload, operational, and safety criteria. The ACS and the LP have been configured to accommodate these systems.

The ACS and LP were designed to accommodate the Zenit-3SL. Due to engineering design requirements specific to the Zenit-3SL, the use of other launch vehicles on SLLP's ACS and LP is not feasible.

These considerations regarding the launch vehicle and Upper Stage remain valid for the license applicant's proposed action and alternatives in this EA.

Figure 2-3
License Applicant's Proposed Action with Avoidance of Oceanic Islands

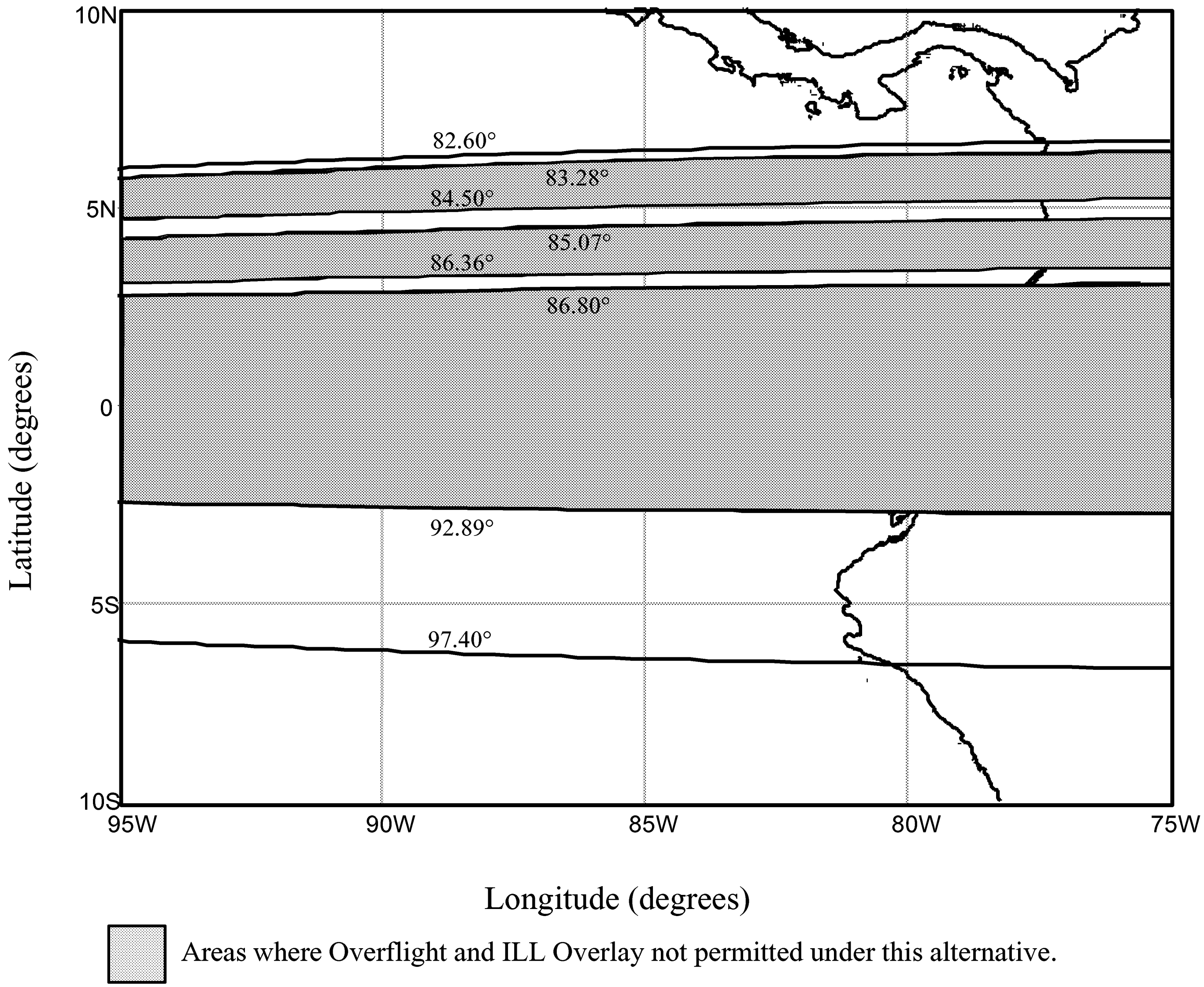
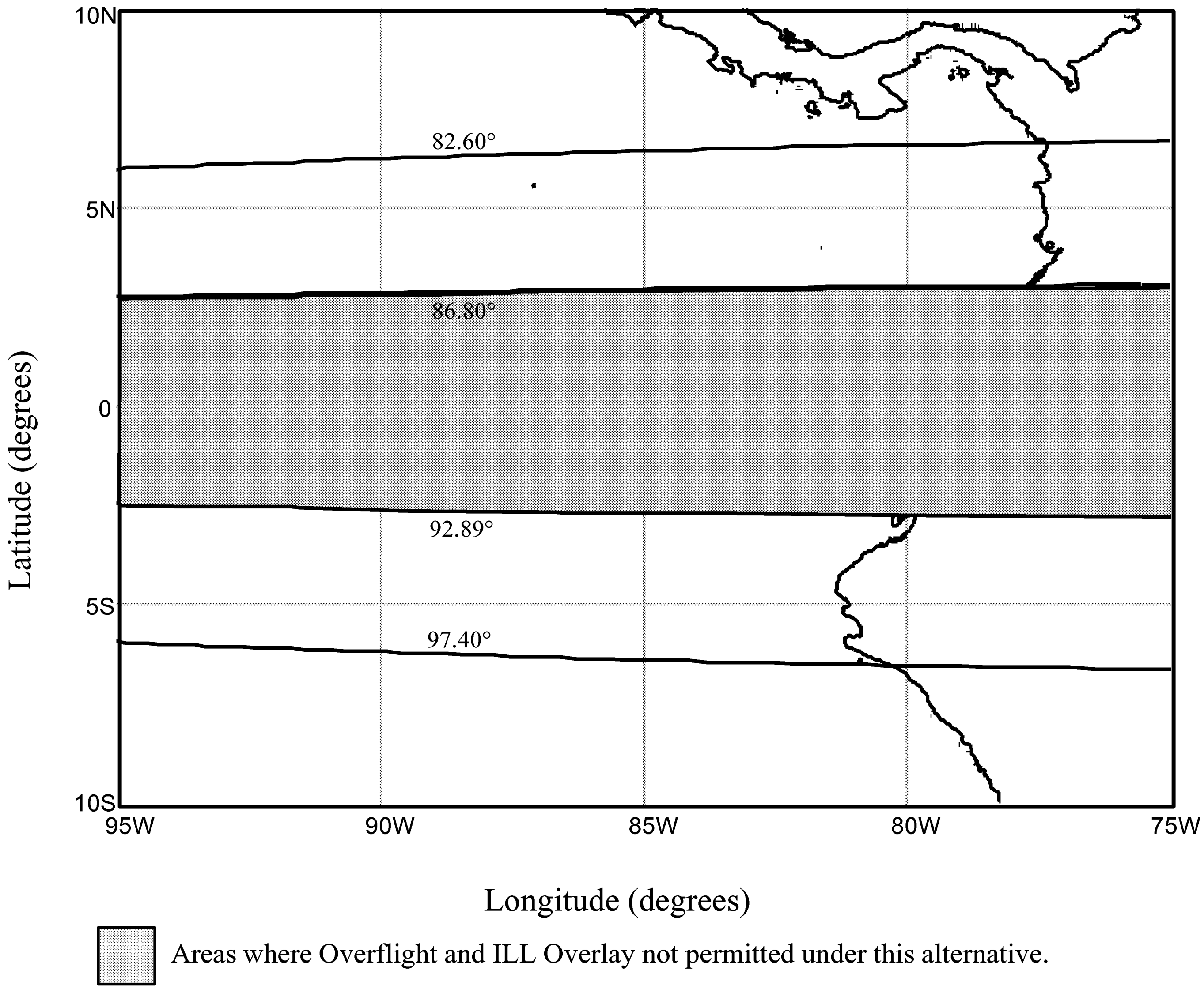


Figure 2-4
License Applicant's Proposed Action with Avoidance of Galapagos Islands



2.4.2 Use of an Alternative Launch Location

Alternative launch locations were previously considered by evaluating public safety, environmental protection, weather conditions, distance from commercial activities (e.g., fishing, recreation, shipping, and air traffic), and proximity to sovereign territories. It was concluded in the February 11, 1999 EA, Section 2.2.2, that these criteria indicated a launch location on the Equator in the east central Pacific Ocean would be most feasible.

For purposes of this EA, these criteria remain relevant and indicate a launch location at or near the Equator in the east central Pacific Ocean as optimal. The recommended launch site at 0° latitude and 154° W longitude is sufficiently distant from any populated areas (i.e., it is over 6,800 km [4,300 miles] from the Galapagos Islands, which are the closest inhabited areas along the flight path). This site was selected, in part, to ensure that spent stage and fairing deposition would only occur in the open ocean to minimize risk to human populations. The launch location also minimizes risk to wildlife populations that are similarly concentrated on land or in coastal waters.

2.5 NO ACTION ALTERNATIVE

Under the No Action alternative, the FAA would not issue an LOL for eight launches per year for five years, for a maximum of 40 launches, for azimuths from 82.6° and 97.4°, inclusive. Because SLLP is a foreign entity controlled by a United States citizen, it must obtain a launch license from the FAA. Thus, under the no action alternative, SLLP would need to continue to apply for launch-specific licenses for each proposed launch (up to six launch-specific licenses per year, or an average of one application every 60 days)[c]. For each proposed launch that would use an azimuth different from that considered in the February 11, 1999 EA, the FAA would need to consider the environmental effects and prepare the appropriate environmental documentation.

2.6 ALTERNATIVES EVALUATED DURING SCREENING PROCESS

2.6.1 Screening Methodology

The FAA completed a thorough and objective review of reasonable alternatives to the license applicant's proposed action. CEQ regulations require that an agency look at "reasonable" alternatives to the license applicant's proposed action. With that standard in mind, the FAA did not evaluate in detail those alternatives that showed no possibility of meeting the purpose and need of the license applicant's proposed action, as described in Section 1.3.

The screening methodology utilizes an evaluation process formulated to concentrate on the purpose and need for the license applicant's proposed action and the reasonableness of the alternatives. Alternatives that do not meet the purpose and need were eliminated from further consideration. Alternatives that meet the purpose and need were considered in detail. An evaluation of each alternative in terms of the screening criteria is provided below.

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[c] An individual who is a United States citizen or an entity organized or existing under the laws of the United States or any state must obtain a license to launch a launch vehicle outside of the United States or a license to operate a launch site outside of the United States. 14 CFR 413.3 (c).

2.6.1.1 License Applicant's Proposed Action

- *Promote economic growth and entrepreneurial activity through use of the space environment for peaceful purposes:* The license applicant's proposed action would promote entrepreneurial activity because it would provide a range of azimuths deemed necessary to meet predicted market demand for GSO launches. The ability to launch on a directly equatorial azimuth (i.e., 90º) would be unique worldwide and would offer commercial satellite customers a highly desirable launch option.

  A 90º azimuth is cost-effective and poses less risk of failure as it eliminates the need for maneuvers to remove orbital inclination. GSO satellites that are launched directly into an equatorial transfer orbit do not need to expend fuel to remove orbit inclination (they do however, expend some fuel, to raise their orbit to their final locations). Procedures associated with removing orbital inclination increase the time used by the satellite to reach its final orbit, by as much as a few weeks, resulting in additional cost and lost revenues for the satellite owner. The fuel expended to remove orbital inclination also shortens the useful life of the functioning satellite by approximately 10 to 15 percent for heavy payloads (Gailey, 2001). In addition, the maneuvers required to remove the orbital inclination of heavy payloads are more complex than those required to raise the orbit, and, therefore, increase the risk of an on-orbit anomaly or failure and orbital debris.

- *Encourage the U.S. private sector to provide launch vehicles, reentry vehicles, and associated services by simplifying and expediting the issuance of licenses:* The license applicant's proposed action would encourage the private sector to provide launch vehicles and launch services by providing a long-term license that would simplify and expedite licensing. The issuance of an LOL would allow SLLP to conduct up to eight launches within specific launch parameters per year for five years. It would reduce the amount of time needed to prepare, submit and review license applications by allowing a more efficient licensing process while still assuring safety and environmental review.

  The option of issuing an LOL, as opposed to requiring a launch-specific license for every launch, provides advantages both to the FAA and the licensee. Although the resources spent to prepare and review an LOL application are likely to be greater than those required for a launch-specific license, this type of license will ultimately result in cost and schedule savings by reducing the number of applications that the FAA must review and that a commercial entity with an active launch schedule must submit. 64 Fed. Reg. 19,594, 19,595; Apr. 21, 1999.

- *Provide FAA oversight and coordination of licensed launches and to protect the public health and safety, the safety of property, and U.S. national security and foreign policy interests of the U.S.:* The license applicant's proposed action requires FAA oversight through the LOL licensing process, which includes both safety and environmental reviews. Additionally, pursuant to FAA regulations, SLLP will be required to notify the FAA of each specific launch and to provide launch-specific information should the FAA issue the proposed LOL (see14 CFR 415). Should any of the proposed LOL parameters change, the FAA would require additional environmental and safety documentation and analyses. The SLLP launch infrastructure and operating procedures to be used under the license applicant's proposed action have been successful in six missions to date. The FAA has closely monitored all missions and SLLP's operations have resulted in no health or safety issues and the results of the environmental monitoring program have confirmed that the environmental impacts of the earlier missions have been insignificant.

The license applicant's proposed action also is consistent with U.S. national security and foreign policy interests. Reliable access to space, as provided under the license applicant's proposed action, promotes U.S. national security. National Space Policy, Fact sheet, Space Transportation (Sept. 19, 1996). Moreover, the SLLP launch procedures incorporate U.S. Government approved national security safeguards. The proposed SLLP launches are consistent with U.S. treaty obligations, including the Convention for the Protection of the Natural Resources and Environment in the South Pacific Region (done November 24, 1986; entered into force August 22, 1990) and the Agreement Establishing the South Pacific Regional Environment Programme (done June 16, 1993; entered into force August 21, 1995).

- *Facilitate the strengthening and expansion of the U.S. space transportation infrastructure:* The license applicant's proposed action strengthens and expands U.S. space transportation infrastructure by facilitating the use of an ocean-based launch site in addition to the traditional land-based U.S. Federal launch facilities. SLLP is the only equatorial launch site offered by a U.S. launch services provider. Thus, the license applicant's proposed action would expand U.S. space transportation infrastructure options for potential customers by providing an additional launch site choice.

The license applicant's proposed action satisfies all of the screening criteria and will, therefore, be analyzed in this EA. The license applicant's proposed action includes the possibility of the FAA issuing a launch-specific license to SLLP for the launch of Galaxy IIIC, as well as other potential launch-specific licenses (not to exceed 8 per year) as necessary should the proposed LOL not be issued or be delayed. The conduct that would be authorized under the proposed LOL and launch-specific licenses is identical, only the license application process would differ. Therefore, discussions and analyses of potential environmental impacts of the proposed LOL and the proposed launch-specific licenses are addressed together. Throughout the document, when the license applicant's proposed action is discussed, while emphasis is placed on the launch operator license, it is understood that the launch-specific licenses are included in the license applicant's proposed action.

2.6.1.2 Alternative Allowing up to 12 Launches per Year

- *Promote economic growth and entrepreneurial activity through use of the space environment for peaceful purposes:* This alternative would promote entrepreneurial activity by providing a range of azimuths sufficient to allow SLLP to meet projected market demand for GSO launches.

- *Encourage the U.S. private sector to provide launch vehicles, reentry vehicles, and associated services by simplifying and expediting the issuance of licenses:* This alternative would encourage the private sector to provide launch vehicles and services in the same manner as the license applicant's proposed action discussed above.

- *Provide FAA oversight and coordination of licensed launches and to protect the public health and safety, the safety of property, and U.S. national security and foreign policy interests of the U.S.:* This alternative would be reviewed for safety purposes through the FAA's licensing process. Any changes to SLLP's operations would need FAA's approval (i.e., the FAA is the authority for commercial launch licenses and will not license any launch that does not demonstrate a requisite level of safety and required environmental review).

- *Facilitate the strengthening and expansion of the U.S. space transportation infrastructure:* Although this alternative would appear on its face to expand U.S. space transportation infrastructure in that it would increase the use of an ocean-based launch site in addition to traditional land-based U.S. Federal and commercial launch facilities, SLLP does not currently have the infrastructure to support this schedule. SLLP currently does not have the infrastructure or operating procedures in place to support this level of launch activity without fundamental changes. For example, the LP would not have time to travel to and from the launch site to support an accelerated schedule. Thus, the turnaround time to process launches this frequently would require a transfer of the launch vehicle from the ACS to the LP somewhere near the launch site. This required change in infrastructure and operating procedures has not been examined; at this time, it is untested and has not been proven to be reliable or safe. Accordingly, this alternative, at this time, cannot facilitate the strengthening or expansion of U.S. space transportation infrastructure.

Therefore, this alternative has been dismissed because it does not meet all of the screening criteria.

2.6.1.3 Alternative with a Range of Azimuths Between 70° and 110°

- *Promote economic growth and entrepreneurial activity through use of the space environment for peaceful purposes:* This alternative might promote entrepreneurial activity by permitting more azimuths than were contemplated under the license applicant's proposed action in addition to permitting the range of azimuths between 82.6° and 97.4°.

  However, entrepreneurial launch activity, such as the SLLP project, will be promoted only to the extent that customer demand exists for the proposed launch services. The commercial launch industry is driven by the demands of satellite manufacturers and owners for the cost-effective delivery of the satellites to specific and well-defined orbits that are useful for the services that their companies provide. Accordingly, it is critical for launch service providers to provide service offerings that meet market requirements. At this time there appears to be limited demand projected for launches at slightly inclined attitudes, i.e., ranging from 70° to 82.6° and 97.4° to 110°. Therefore, because no market exists for this alternative, it does not meet the intent of promoting economic growth.

  In addition, this alternative would—for certain azimuths—require additional fuel expenditures and potentially risky on-orbit maneuvers that could lead to other problems (e.g., failures with increased orbital debris). The use of certain slightly inclined azimuths would require extensive, additional maneuvers to move satellites into their final GSO. Procedures associated with removing orbital inclination increase the time used by the satellite to reach its final orbit, by as much as a few weeks, resulting in increased cost and lost revenues for the satellite owner. The fuel expended to remove orbital inclination also shortens the useful life of the functioning satellite by approximately 10 to 15 percent for heavy payloads (Gailey, 2001). This alternative would not promote economic growth and entrepreneurial activity in the same manner as the license applicant's proposed action.

- *Encourage the U.S. private sector to provide launch vehicles, reentry vehicles, and associated services by simplifying and expediting the issuance of licenses:* This alternative would encourage the private sector to provide launch vehicles and services in the same manner as the license applicant's proposed action.

- *Provide FAA oversight and coordination of licensed launches and to protect the public health and safety, the safety of property, and U.S. national security and foreign policy interests of the U.S.:* This alternative would be reviewed for safety purposes through the FAA's licensing process.

- *Facilitate the strengthening and expansion of the U.S. space transportation infrastructure:* This alternative would strengthen and expand the U.S. space transportation infrastructure to the same extent as the license applicant's proposed action.

This alternative would not promote economic growth and entrepreneurial activity for all the azimuths in the proposed range. Further, the additional maneuvers required to move satellites into their final GSO, while they are not as extreme as for a fully inclined azimuth (see Section 2.3), would still increase risk of a failure or anomaly. Such a failure or anomaly could create orbital debris. Moreover, this alternative would not provide advantage to commercial customers beyond the license applicant's proposed action. Consequently, this alternative was not evaluated further.

2.6.1.4 Alternative with Avoidance of National Parks and National Reserves

- *Promote economic growth and entrepreneurial activity through use of the space environment for peaceful purposes:* This alternative would promote entrepreneurial activity through the use of space for peaceful purposes. However, it involves a restricted range of azimuths compared to the license applicant's proposed action that would limit commercial flexibility to meet market demand. Avoiding overflights of all national parks and reserves within the azimuth range of 82.6º to 97.4º would only leave 2.16º of the range available for commercial use. There are no potential azimuths in the 82.6º to 97.4º range that would avoid concern regarding national parks and reserves when ILLs are taken into account.[d]

- *Encourage the U.S. private sector to provide launch vehicles, reentry vehicles, and associated services by simplifying and expediting the issuance of licenses:* Issuing an LOL to allow SLLP to conduct up to eight launches per year for five years, would simplify and expedite commercial launch licensing. However, an LOL for such a narrow range of azimuths would mean that SLLP would still have to obtain a launch-specific license for each launch along any azimuth outside the narrow range identified that would avoid overflights.

- *Provide FAA oversight and coordination of licensed launches and to protect the public health and safety, the safety of property, and U.S. national security and foreign policy interests of the U.S.:* This alternative would be reviewed for safety purposes through the FAA's licensing process.

- *Facilitate the strengthening and expansion of the U.S. space transportation infrastructure:* This alternative would strengthen and expand the U.S. space transportation infrastructure to the extent that it would provide for the use of an ocean-based launch site in addition to traditional land-based U.S. Federal launch facilities.

This alternative does not meet the screening criteria, is not considered feasible and will not be evaluated further in this EA. The restricted range of azimuths compared to the license applicant's

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[d] It should be noted that FAA has licensed other SLLP missions where the ILLs overlay environmentally sensitive areas.

proposed action that would limit commercial flexibility to meet market demand. The narrow range of azimuths proposed under this alternative would severely restrict commercial operations and would not simplify or expedite the FAA's licensing of commercial launches.

2.6.1.5 Alternative with Avoidance of the Oceanic Islands

- *Promote economic growth and entrepreneurial activity through use of the space environment for peaceful purposes:* This alternative would promote entrepreneurial activity in that it would provide a range of azimuths sufficient for SLLP to meet a portion of the projected GSO launch market demand. However, this alternative would preclude azimuths that require overflight of the Galapagos Islands, Malpelo Island and Cocos Island, and therefore GSO launches would require limited maneuvers with some risk involved, to remove orbital inclination. These maneuvers would further require additional fuel consumption and transit time for the payload to reach its final orbit. While this is not optimal, it would still allow a range of azimuths and provide for greater opportunity for entrepreneurial activity than SLLP's currently authorized operations.

- *Encourage the U.S. private sector to provide launch vehicles, reentry vehicles, and associated services by simplifying and expediting the issuance of licenses:* This alternative would encourage the private sector to provide launch vehicles and services through a simplified and expedited licensing procedure. This proposed alternative would involve the issuance of an LOL that would allow SLLP to conduct up to eight launches per year for five years for the general range of azimuths identified in the license applicant's proposed action with the exception of those azimuths that would require overflight of the Galapagos Islands, Malpelo Island, and Cocos Island. Such an LOL would relieve SLLP of having to apply for individual launch-specific licenses along the approved azimuth ranges in the LOL, thus simplifying and expediting the licensing process. SLLP would still have to pursue launch-specific licenses for proposed launches along any azimuth outside this range.

- *Provide FAA oversight and coordination of licensed launches and to protect the public health and safety, the safety of property, and U.S. national security and foreign policy interests of the U.S.:* This alternative would be reviewed for safety purposes through the FAA's licensing process.

- *Facilitate the strengthening and expansion of the U.S. space transportation infrastructure:* This alternative strengthens and expands U.S. space transportation infrastructure in the same manner as the license applicant's proposed action.

This alternative, even though not optimal from an operating flexibility standpoint, satisfies the screening criteria and is therefore considered a reasonable alternative to analyze in this EA.

2.6.1.6 Alternative with Avoidance of the Galapagos Islands

- *Promote economic growth and entrepreneurial activity through use of the space environment for peaceful purposes:* This alternative would promote entrepreneurial activity in that it would provide a range of azimuths sufficient for SLLP to help meet most projected GSO launch market demand. This alternative would preclude azimuths that require overflight of the Galapagos Islands, and therefore GSO launches would require limited maneuvers with some additional risk, to remove orbital inclination. These maneuvers would require additional fuel consumption and transit time for the payload to reach its final orbit.

- *Encourage the U.S. private sector to provide launch vehicles, reentry vehicles, and associated services by simplifying and expediting the issuance of licenses:* This alternative would encourage the private sector to provide launch vehicles and services through a simplified and expedited licensing procedure. This proposed alternative would involve the issuance of a LOL that would allow SLLP to conduct up to eight launches per year for five years along a range of azimuths similar to the license applicant's proposed action but excluding those requiring overflight of the Galapagos Islands. This alternative would relieve the license applicant and the FAA from conducting the launch-specific license application process for proposed launches within the LOL-specified azimuth ranges.

- *Provide FAA oversight and coordination of licensed launches and to protect the public health and safety, the safety of property, and U.S. national security and foreign policy interests of the U.S.:* This alternative would be reviewed for safety purposes through the FAA's licensing process.

- *Facilitate the strengthening and expansion of the U.S. space transportation infrastructure:* This alternative would strengthen and expand the U.S. space transportation infrastructure in the same manner as the license applicant's proposed action discussed above.

This alternative, even though not optimal from an operating flexibility standpoint, satisfies the screening criteria and is therefore considered a reasonable alternative to analyze in this EA.

2.6.2 Alternatives Studied in Detail

Based on the screening process described above, three alternatives are identified as reasonable (i.e., satisfy the screening criteria defined in Section 2.1) and are evaluated in detail in this EA. These alternatives are:

- License applicant's proposed action – issuance of a LOL for up to eight launches per year for five years with launch azimuths between 82.6° and 97.4° and a launch-specific license for one mission with a launch azimuth of 90° (Galaxy IIIC);
- Alternative with avoidance of the Oceanic Islands; and
- Alternative with avoidance of the Galapagos Islands.

Based on the requirements of E.O. 12114 as guided by NEPA, the EA also evaluates the No Action alternative.

Each of these alternatives is evaluated in Section 4 of this EA.

3.0 AFFECTED ENVIRONMENT

3.1 OVERVIEW

Under the license applicant's proposed action and the alternatives, all launches would originate from the SLLP LP in the Pacific Ocean, 425 km (266 mi) southeast of Kiritimati (Christmas) Island of the Kiribati Island Group, at 0° latitude and 154° W longitude. The launch location is the same as described in Sections 2.1 and 3.0 of the February 11, 1999 EA (see Appendix A). This EA discusses the area potentially affected by the license applicant's proposed action and the reasonable alternatives to that action.

For purposes of this EA, the affected environment is based on an area defined on and above the Earth's surface by the proposed azimuth range of 82.6° to 97.4°. The affected environment would include the geographic area extending from the LP to the east coast of South America, beyond which the payload would be orbital and no further effects on land or water are expected to occur. The area potentially affected by the proposed launches includes all land, water, and the atmosphere between 7.4º N and 7.4º S of the equator and between the launch location and the eastern coast of South America (see Figure 3-1). This area encompasses approximately nine million km^2 (3.5 million mi^2) of the equatorial Pacific Ocean and five million km^2 (1.9 million mi^2) of South America. The vast majority of the marine area is deep, open portions of the Pacific Ocean, though the proposed range of flightpaths includes overflights of the Galapagos Islands, Cocos Island, and Malpelo Island. Further east, the area of the South American flyover encompasses several ecosystems, including Pacific coastal lowlands, the Andean mountain range, and much of the Amazon River basin.

In previous missions orbit parameters were known in detail, in advance, and were evaluated on a mission-specific basis, which included delineation of ILL. ILLs are based on a statistical analysis showing where, with greater than 99.67 percent certainty (i.e., based on three standard deviations or 3 σ), Zenit-3SL stages and debris from a failed mission would fall. In considering the potential impacts of possible failure scenarios, the ILLs for the outer most azimuths of the proposed 82.6° to 97.4° range have been calculated and are used to set the "boundaries" of the potentially impacted ocean and landmass areas given the range of potential missions that could be carried out under the license applicant's proposed action.

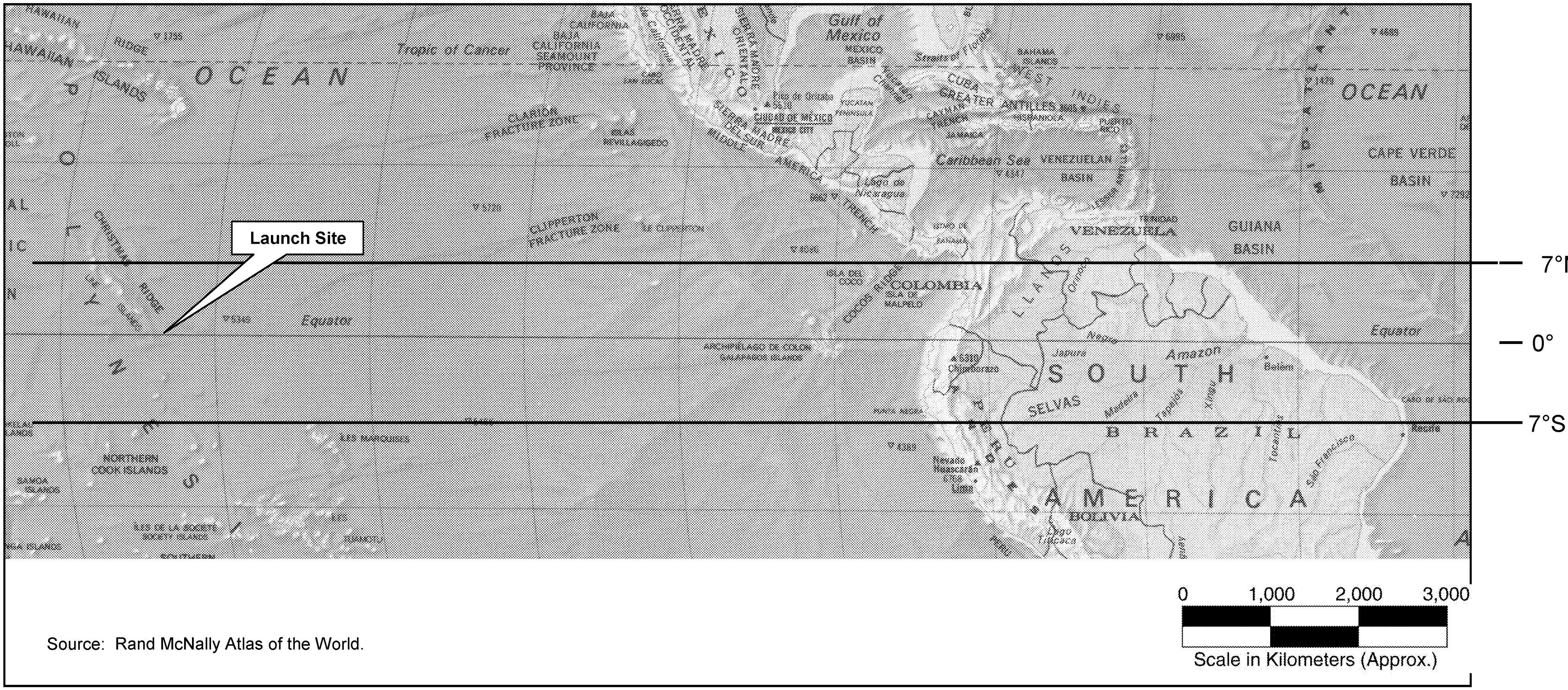
This section of the EA is organized according to geographic area and describes existing or baseline environmental conditions for the open ocean, Oceanic Islands, and continental South America. It should be noted that for the 83° azimuth, the ILL overlays a small portion of Central America; however, this landmass would not be overflown by the ILV and would only be potentially of concern given a failure of the Upper Stage as discussed in Section 4.

3.2 GEOGRAPHIC AREAS

3.2.1 Open Ocean

Approximately nine million km^2 (3.5 million mi^2) of open ocean are included within the affected environment. This section provides an overview of the geology, atmospheric processes, oceanography, biological communities, and commerce of the equatorial Pacific Ocean. Other aspects of the affected environment — such as visual resources, social conditions, and cultural

Figure 3-1
Affected Environment - From Launch Site to Eastern South America (7° north to 7° south)



Source: Rand McNally Atlas of the World.

resources — are not applicable because there are no human inhabitants of this area and it is the site of occasional commercial shipping or fishing.

3.2.1.1 Geology

The lithosphere in the equatorial Pacific region is broken up into roughly two dozen plates, which create various features on the ocean floor, such as ridges, trenches, and volcanoes. The region east of the launch location consists of three main tectonic plates: the Nazca Plate, moving east toward the South American Plate; the Cocos Plate, moving north; and the Pacific Plate, moving west. The Galapagos Spreading Center — also known as the Galapagos Rift — located just north of the Galapagos Archipelago, is a mid-ocean ridge formed by the edges of plates moving away from each other. The rift has a major transform fault located just north of the Galapagos Islands at 91° W. A major subduction zone, where the plates discussed above are colliding, is located along the west coast of Central and South America, and is marked by deep trenches and overlying chains of volcanoes (Clapperton, 1993). The movement of the Nazca Plate produced a chain of seamounts known as the Carnegie Ridge. A second seamount chain, the Cocos Ridge, extends northeast from the Galapagos Spreading Center (see Figure 3-2).

3.2.1.2 Atmospheric Processes and Conditions

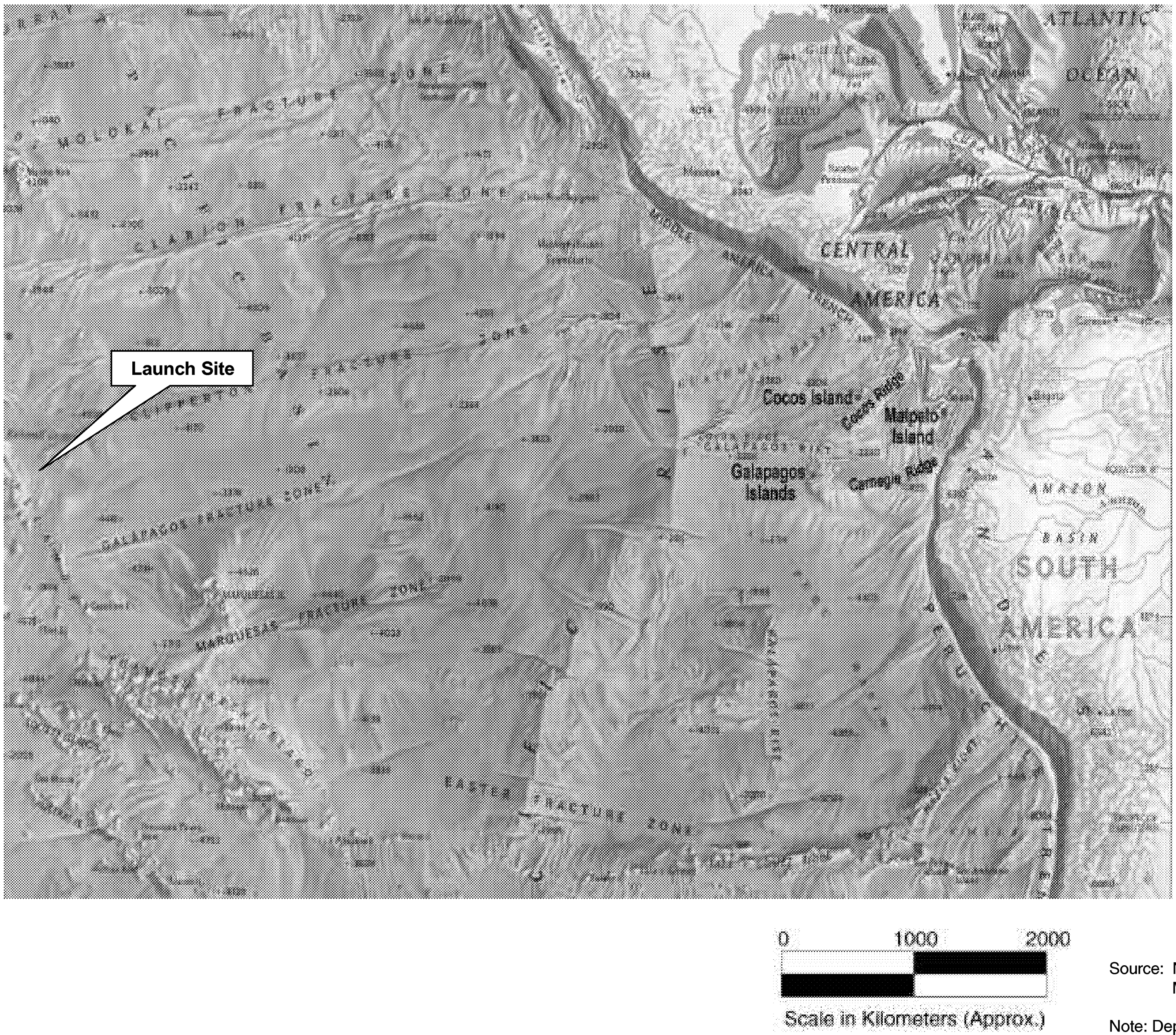
In the eastern portion of the Pacific, the atmosphere and ocean continually interact in physical and chemical cycles. Ocean surface temperatures play a large role in atmospheric conditions. A daily cycle of solar heat drives convective mixing. Convective mixing occurs as a result of changes in water stability, i.e., when surface water becomes denser than subsurface water an unstable condition exists. In this case the surface water sinks and the subsurface water rises to the surface thus creating a mixing effect. In addition, regional trade winds from the east push equatorial surface water into a mound in the west-equatorial Pacific Ocean which affects atmospheric conditions. For still unknown reasons, the trade winds occasionally weaken, causing a reverse flow of warm surface waters to the east which then mound against South America. The additional pressure of warm water in the east-equatorial Pacific Ocean inhibits and slows the upwelling of the more dense, cold, and nutrient-rich deep ocean water (Philander, 1992; and Lukas, 1992) in a phenomenon known as the El Nino/Southern Oscillation. The El Nino effect includes an extreme decline in ecosystem productivity along the coast of South America, and great fluctuations in heat transfer and molecular exchange between the ocean and the atmosphere throughout the Pacific region (Lukas, 1992). El Nino has little effect on ecosystem productivity in the ocean waters of the launch location and range.

It has been estimated that these processes in the equatorial Pacific region annually cycle 3×10^{11} kilogram (kg) (7×10^{11} pounds (lbs)) of carbon dioxide (CO_2) between the ocean and atmosphere, and about the same amount of particulate carbon settles to the deep ocean waters per year to be replaced by upwelling and the westward equatorial current. (Murray, 1994).

Atmospheric Layers

The atmosphere can be classified into five layers or strata. From the ocean moving upward they are 1) the atmospheric boundary layer or lower troposphere, 2) the free troposphere, 3) the stratosphere, 4) the mesosphere, and 5) the thermosphere (also called the ionosphere). The troposphere is the lowest part of the atmosphere and represents the portion Figure 3-2 of the atmosphere where the frictional effects of the Earth's surface may be substantial.

Figure 3-2
Ocean Floor of the Affected Environment



Source: National Geographic Society
Mercator Projection,

Note: Depths are in meters.

It extends from the surface to approximately 2 km (1.2 mi) above sea level, although the actual height is a function of surface roughness and temperature gradient.

The free troposphere is that portion of the atmosphere extending from the top of the atmospheric boundary layer to the bottom of the stratosphere. Exact elevations are a function of time and location, but for purposes of this analysis, can be taken to be approximately 2 to 10 km (1.2 to 6.2 mi). The free troposphere frequently receives polluted air from the atmospheric boundary layer and, less often, ozone from the stratosphere. Emissions to or entering the free troposphere are subject to photochemical oxidation and chemical reactions within cloud droplets. Most emissions that undergo such chemical reactions are returned to the atmospheric boundary layer or to the Earth's surface by precipitation. The thermal heat balance of the Earth's surface is due in great measure to the regulation of incoming and outgoing radiation by clouds and gases in the free troposphere.

The stratosphere is that part of the atmosphere from approximately 10 to 50 km (6.2 to 31 mi) above the Earth's surface. The temperature of the stratosphere rises from a minimum at its base to a maximum at its top. This increase in temperature is due to the increased absorption of ultraviolet radiation energy by ozone. The stratosphere is the main region of ozone production in the atmosphere, and this ozone plays a critical role in protecting the Earth's surface from ultraviolet radiation and in regulating the Earth's heat energy balance. It is estimated that approximately 3.5×10^8 kg (7.7×10^8 lbs) of ozone are formed and destroyed daily by natural processes in the stratosphere (Manahan, 1994). An ozone molecule is destroyed by the adsorption of ultraviolet radiation energy, which triggers a series of reactions that combine one oxygen atom with one ozone molecule. The destruction of the ozone layer is due in part to the placement of certain chemicals into the stratosphere, primarily as a result of human activities, that serve to catalyze these reactions leading to the destruction of ozone.

Above the stratosphere, the mesosphere extends from approximately 50 to 85 km (31 to 53 mi). Characteristic of the mesosphere is a drop in temperature with an increase in altitude, due to the absence of radiation adsorbing molecules. Above the mesosphere is the thermosphere where the temperature rises because of molecular adsorption of high energy solar radiation.

3.2.1.3 Baseline Noise Conditions

Baseline or ambient noise levels on the ocean surface—not including localized noise attributed to shipping—is a function of local and regional wind speeds. Studies of ambient noise of the ocean have found that the sea surface is the predominant source of noise, and that the source is associated with the breaking of waves (Knudsen, et al., 1948). Wave breaking is further correlated to wind speed, resulting in a relationship between noise level and wind speed (Cato, et al., 1994).

Typical wind speeds for the eastern portion of the Pacific Ocean range from 2 to 13.5 meters/second (m/s) (5 to 30 miles per hour (mph); National Imagery and Mapping Agency (NIMA), 1998, and Cato, et al., 1994). These wind speeds correspond to a noise level range of approximately 55 decibel (dB) to 68dB. At the launch location, the predominant wind speed throughout the year is approximately 8 m/s (18 mph) (NIMA, 1998). This wind speed corresponds to an ambient noise level of 64 dB. Moving eastward from the launch site to the Oceanic Islands, the dominant wind speed decreases from about 8 m/s to roughly 5 m/s (18 mph to 12 mph). Near the Oceanic Islands, the predominant wind speed is approximately 5 m/s

(12 mph) (NIMA, 1998), corresponding to an ambient noise level of 60 dB. Observed seasonal changes in winds usually do not include changes in wind speed but rather wind direction (NIMA, 1998). Storms and other weather events, however, would increase localized wind speed, and therefore would increase the noise level for the duration of that weather event.

3.2.1.4 Oceanography

Open ocean currents in the equatorial Pacific region are driven by the wind and rotation of the Earth (see Figure 3-3). Waters along the coast of South America flow north and west and are referred to as the South Equatorial Current. This current brings relatively cool, high salinity, nutrient-rich waters north from near Antarctica. Waters along the coast of Central America flow south and west and are referred to as the North Equatorial Current. This current brings relatively warm, nutrient-poor, and low salinity waters south.

Between the westerly flowing North and South Equatorial Currents, the surface Equatorial Countercurrent and the subsurface Cromwell Current both flow east, forming a transition zone. Depending on the season, this zone is commonly formed between the latitudes of 2° N and 1° S, which encompasses the Galapagos Islands. Strong vertical mixing occurs along the equator in the region of the Galapagos Islands because of the Equatorial Countercurrent and the upwelling of cool, nutrient-rich waters, which is caused by upward deflection of the subsurface Cromwell Current (Graham, 1975) and divergence in the surface wind field (Figure 3-4). This vertical mixing — together with the presence of shallow water and islands — allows for high biological productivity in the Galapagos region, (Wooster and Hedgpeth, 1966), and abundant marine life.

Coastal upwelling also occurs along the coast of South America, resulting in the biologically active coastal areas that support commercial fisheries (Figure 3-4). Coastal upwelling is common along the margins of continents, where wind conditions are such that adjacent surface waters are carried out to the open ocean via Ekman Transport (wind-driven transport of surface water away from a continental mass).

3.2.1.5 Biological Communities

Three distinct biological communities can be distinguished within the open equatorial Pacific Ocean: marine, hydrothermal vent, and coral reef. Hydrothermal vents are cracks along a rift or ridge in the deep ocean floor that spew water heated to high temperatures by the magma under the Earth's crust. These areas support species that are abnormally large in size given the depths of the vents. These communities are described below.

Figure 3-3
Currents Around the Major Oceanic Islands in the Tropical Pacific Ocean

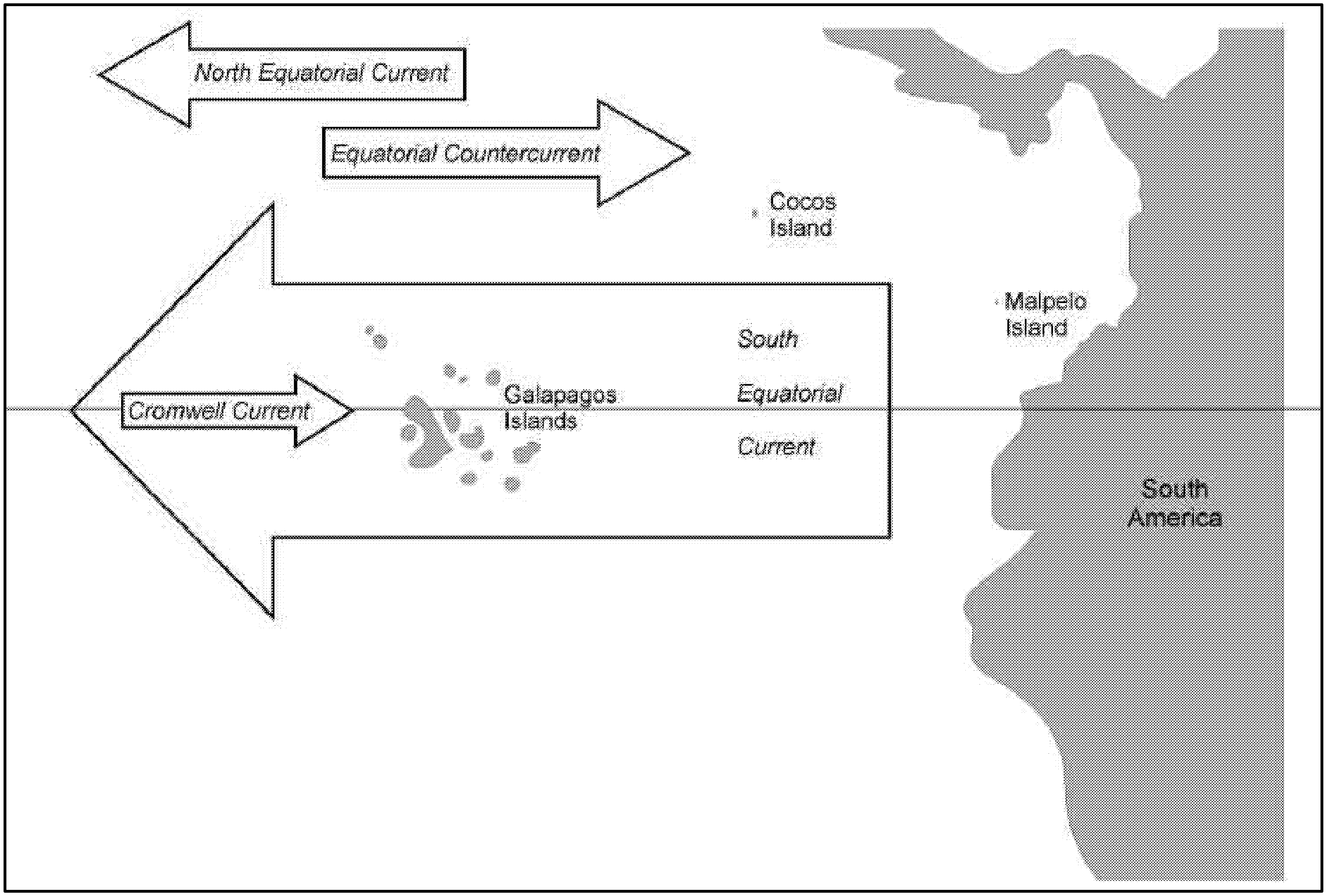
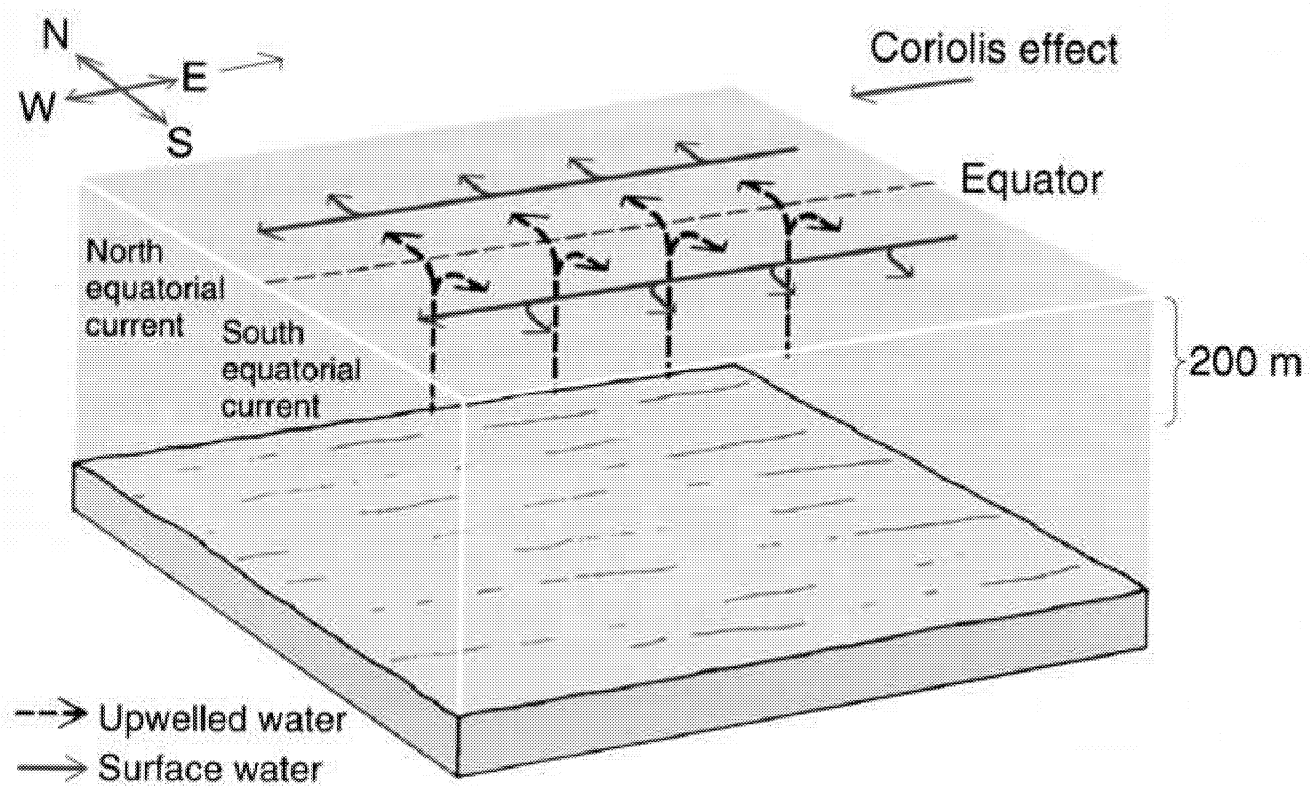


Figure 3-4
Equatorial Upwelling



Marine

Marine species diversity varies throughout the equatorial Pacific region because of the distinct differences in oceanographic processes (e.g., water temperature, and upwelling, as described in Section 3.2.1.3). The marine environment can be divided into the north, south, and transitional ecoregions, which are occupied by distinct groups of marine species.

In the north ecoregion, the North Equatorial Current transports tropical warm waters throughout the year (mean temperature of 20° C or 68° F). This current directly affects the northern Galapagos Islands, the only truly tropical region in the Galapagos, which exhibit high marine species diversity. Common species include the hammerhead shark (*Sphyrna lewini*), reef whitetip shark (*Triaendon obesus*), yellow fin tuna (*Thunnus albacares*), many species of pelagic (i.e., open ocean) fish, and shrimp.

The south ecoregion is dominated by the convergence of the Equatorial Countercurrent and the South Equatorial Current (see Figure 3-3), which — along with mixing winds — causes upwelling of cold (averaging around 15° C or 59° F), nutrient-rich waters. Marine diversity and productivity are high in such areas. Most of the marine species found in these waters originated in the cold waters of the Peruvian and Chilean Coasts. Characteristic species include a diverse variety of shorefish, an abundance of Peruvian anchoveta (*Engraulis ringens*) and pilchard (*Sardinops sagox sagap*), the Galapagos penguin (*Spheniscus mendiculus*), and the Galapagos shark (*Carcharhinus galapagensis*), which are attracted to the upwelled, nutrient-rich waters and corresponding food sources.

The transitional ecoregion is affected by cold water upwellings from the south and warm tropical waters from the north. This region is characterized by species from both the north and south regions, varying according to seasonal water temperature (Darwin Foundation, 2000). During the southern winter, this ecoregion experiences upwellings of cold water; during the southern summer, it experiences influxes of tropical waters.

The marine fauna in the Galapagos, Cocos, and Malpelo Island regions is similar with respect to species composition, with the exception of roughly 60 endemic or native species of shorefish that are restricted to individual islands within the Galapagos and Cocos Islands. No endemic species are known to occur at Malpelo Island (World Conservation Monitoring Center (WCMC), 2000). The marine fauna includes seven species of dolphins, seven species of sharks, four species of rays, and over 600 species of mollusks (WCMC, 2000). Roughly 298 fish species in 88 families have been recorded in the region. Shorefish exhibit high rates of endemism (approximately 23 percent) (Wolda, 1985).

Several species of migratory fish, reptiles, and mammals are found throughout these three marine ecoregions at various times of the year, including tuna, sea turtles, and whales.

Hydrothermal Vent

Diverse biological communities are associated with hydrothermal vents that occur along the Galapagos Rift spreading center. The organic content of the water in these areas is roughly 500 times greater than the normal bottom environment and four times greater than in typical surface waters (Thurman, 1988). Water temperatures in the immediate area of the vents range from 8° to 12° C (46° to 54° F), while the normal sea bottom temperature at this depth is usually 2° C (36° F).

These vent communities consist of unusually large organisms for these depths, with the most prominent members being pogonaphoran worms (*Rifta pachyptila*) with tubes over 1 m (3.3 ft) long, and giant clams (*Calyptogena magnifica*) over 25 centimeter (cm) (10 inch (in)) in length (Thurman, 1988).

The warm water that flows from the hydrothermal vents is rich in hydrogen sulfide. Chemosynthetic bacteria, which form the base of the food chain, use the energy released by their oxidation of hydrogen sulfide to fix carbon dioxide into organic matter. This process allows the bacteria to replace photosynthetic phytoplankton as the primary producers of organic matter in the otherwise desolate regions of the deep ocean (Thurman, 1988).

Coral Reef

Coral reefs in the eastern Pacific are poorly developed and have low species diversity when compared with those of the central and western Pacific (Glynn and Ault, 2000). This is primarily attributable to the lower water temperatures of the eastern Pacific, where ocean temperatures average 3° C (5° F) cooler than in the western Pacific (Durham, 1966), and to a relative lack of underwater platforms on which reefs can form. Corals in this area do not generally form true reef frameworks, but instead attach themselves to existing underwater structures (e.g., walls of underwater volcanoes). In a few locations, corals of the genus *Pocillopora* form reef-like frameworks (Durham, 1962).

Forty-four species of stony corals have been recorded in the Galapagos, 31 from Cocos, and seven from Malpelo (Glynn and Ault, 2000; Durham, 1962). In total, 52 species are known from these areas, with seven species common to all three island groups (Table 3-1).

The fringing reefs of Cocos Island are some of the more extensive and rich in the eastern equatorial Pacific (though still much less diverse than in the central or western Pacific). This diversity may be attributed to their location in the consistently warm waters of the north ecoregion (Guzman and Cortes, 1992; Durham, 1992). Twenty-eight species of corals are found in the Cocos reefs, the most abundant being *Porites californica* (Guzman and Cortes, 1992). Other common species include *Pocillopora robusta,* which occurs in small scattered patches at depths of one to eight meters, and *Tubastrea aurea,* which is common at various depths. The 1982-1983 El Niño phenomenon seriously affected the coral reefs of Cocos Island, causing about 90 percent of the coral to die. Although there are signs of recovery of the coral communities, it is evident that the intense feeding of sea urchins has weakened the coral foundation (de Alessi, 1997).

The Malpelo coral reef community contains seven species, none of which are endemic. Although coral growth is dense, no true coral reef is formed. The coral is interspersed among large barnacle clusters on the steeply sloping submerged walls of the volcano (Birkeland et al., 1985). At Malpelo, corals occur to depths of 30 m (100 ft); coral growth at this depth is attributed to the clear water around the island (Birkeland et al., 1985).

TABLE 3-1. STONY CORAL SPECIES OF THE GALAPAGOS, COCOS, AND MALPELO ISLANDS

Scientific Name	Location	Scientific Name	Location
Astrangia dentata	Cocos	*Pavona clivosa*	Galapagos
Astrangia eguatorialis	Galapagos	*Pavona explanulata*	Cocos
Astrangia gardnerensis	Galapagos	*Pavona gigantea*	Galapagos, Cocos
Astrangia hondaensis	Galapagos, Cocos	*Pavona maldirensis*	Galapagos, Cocos
Balanophyllia galapagensis	Galapagos	*Pavona ponderosa*	Cocos
Balanophyllia osburni	Galapagos	*Pavona varians*	Galapagos, Cocos, Malpelo
Carpophyllia diomedae	Galapagos	*Pavona varifae*	Cocos
Cindocora debilis	Galapagos, Cocos	*Pacillopora capitata*	Galapagos, Cocos
Cycloseris curvata	Galapagos, Cocos	*Pocillopora damicornis cespitosa*	Galapagos
Cycloseris elegans	Galapagos	*Pocillopora damicornis*	Galapagos, Cocos
Cycloseris mexicana	Galapagos, Cocos	*Pocillopora elegans*	Galapagos, Cocos, Malpelo
Desmophyllum galapagense	Galapagos	*Pocillopora eydouxi*	Galapagos, Cocos, Malpelo
Diaseris distorta	Galapagos, Cocos	*Pocillopora inflata*	Galapagos
Endopachys vaughani	Galapagos, Cocos	*Pocillopora meandrina*	Galapagos, Cocos
Flahellum daphnense	Galapagos	*Pocillopora verrucosa*	Galapagos, Cocos, Malpelo
Gardineroseris phamlota	Galapagos, Cocos, Malpelo	*Porites excavata*	Cocos
Kionotrochus avis	Galapagos	*Porites lobata*	Galapagos, Cocos, Malpelo
Kionotrochus hoodensis	Galapagos	*Psammocora brighami*	Galapagos
Leploseris digitata	Cocos	*Psammocora profundacella*	Galapagos, Cocos
Leploseris popvrucea	Cocos	*Psammocora stellata*	Galapagos, Cocos
Leploseris scabra	Galapagos, Cocos	*Psammocora superficialis*	Galapagos, Cocos
Lophosmilla wellsi	Galapagos	*Ralanophyllia osburni*	Galapagos
Madraeis asperula	Galapagos	*Ralanophyllia scheeri*	Cocos
Madraeis sp.	Galapagos	*Sphenotrochus hancocki*	Galapagos
Mudrepora galapagensis	Galapagos	*Thecopsammia pourtalesi*	Galapagos
Pavona clavus	Galapagos, Cocos, Malpelo	*Tubastrea tenuilamellosa*	Galapagos, Cocos

3.2.1.6 Threatened and Endangered Species

International lists of threatened, endangered, and vulnerable species and special habitats were consulted in addition to lists maintained by the U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service. Lists are maintained by international conservation organizations, including the International Union for Conservation of Nature and Natural Resources (IUCN) and the WCMC. The most comprehensive of these lists is the IUCN Red List of Threatened Animals (IUCN, 2000).

Table 3-2 lists threatened, endangered, or vulnerable, species of reptiles, birds, and mammals that could occur within the affected environment, as well as their listing agency or organization and their current status.

TABLE 3-2. THREATENED AND ENDANGERED* SPECIES THAT COULD OCCUR WITHIN THE AFFECTED ENVIRONMENT

Scientific Name	Common Name	Listing Agency/ Organization	Current Listing Status	Occurrence Within Study Area
Reptiles				
Conolophus pallidus	Barrington land iguana	USFWS, IUCN	Vulnerable	Oceanic Islands
Geochelone elephantopus abingdoni	Pinta Galapagos giant tortoise	USFWS, IUCN, WCMC	Extinct in the Wild	Oceanic Islands
Geochelone elephantopus becki	Galapagos giant tortoise	USFWS, IUCN, WCMC	Vulnerable	Oceanic Islands
Geochelone elephantopus chathamensis	Galapagos giant tortoise	USFWS, IUCN, WCMC	Vulnerable	Oceanic Islands
Geochelone elephantopus darwini	Galapagos giant tortoise	USFWS, IUCN, WCMC	Endangered	Oceanic Islands
Geochelone elephantopus elephantopus	Galapagos giant tortoise	USFWS, WCMC	Endangered	Oceanic Islands
Geochelone elephantopus ephippium	Galapagos giant tortoise	USFWS, IUCN, WCMC	Extinct in the Wild	Oceanic Islands
Geochelone elephantopus guntheri	Galapagos giant tortoise	USFWS, IUCN, WCMC	Endangered	Oceanic Islands
Geochelone elephantopus hoodensis	Galapagos giant tortoise	USFWS, IUCN, WCMC	Critically endangered	Oceanic Islands
Geochelone elephantopus microphyes	Galapagos giant tortoise	USFWS, IUCN, WCMC	Vulnerable	Oceanic Islands
Geochelone elephantopus phantastica	Galapagos giant tortoise	USFWS, WCMC	Endangered/possibly extinct	Oceanic Islands
Geochelone elephantopus porteri	Galapagos giant tortoise	USFWS, IUCN, WCMC	Endangered	Oceanic Islands
Geochelone vicina	Iguana Cove Tortoise	IUCN	Endangered	Oceanic Islands
Geochelone elephantopus vandenburghi	Galapagos giant tortoise	USFWS, IUCN, WCMC	Vulnerable	Oceanic Islands
Lepidochelys olivacea	Olive Ridley sea turtle	USFWS	Endangered	Oceanic Islands, open ocean
Chelonia mydas	Green turtle	USFWS, IUCN	Endangered	Oceanic Islands, open ocean
Eretmochelys imbricata	Hawksbill sea turtle	USFWS, IUCN	Critically endangered	Oceanic Islands, open ocean
Amblyrhynchus cristatus	Galapagos marine iguana	IUCN, WCMC	Vulnerable	Oceanic Islands, open ocean
Dermochelys coriacea	Leatherback turtle	USFWS, IUCN	Critically endangered	Oceanic Islands, open ocean

Scientific Name	Common Name	Listing Agency/ Organization	Current Listing Status	Occurrence Within Study Area
Conolophus subcristatus	Galapagos land iguana	IUCN	Vulnerable	Oceanic Islands
Mammals				
Nesoryzomys fernandinae	Fernandina rice rat	IUCN	Vulnerable	Oceanic Islands
Physeter catodon	Sperm whale	USFWS	Endangered	Open ocean
Orcinus orca	Killer whale	IUCN	Lower risk	Open ocean
Globicephalia macrorhynchus	Pilot whale	USFWS, IUCN	Lower risk	Open ocean
Megaptera novaeangliae	Humpback whale	USFWS, IUCN	Vulnerable	Open ocean
Balaenoptera physalus	Finback whale	USFWS, IUCN	Endangered	Open ocean
Balaenoptera musculus	Blue whale	IUCN	Endangered	Open ocean
Balaenoptera borealis	Sei whale	USFWS, WCMC	Endangered	Open ocean
Balaenoptera acutorostrata	Minke whale	USFWS, IUCN	Lower Risk	Open ocean
Stenella coeruleoalba	Striped dolphin	WCMC	Lower risk	Open ocean
Zalophus californianus wollebaeki	Galapagos sea lion	IUCN	Vulnerable	Oceanic Islands, open ocean
Arctocephalus galapagoensis	Galapagos fur seal	IUCN	Vulnerable	Oceanic Islands, open ocean
Birds				
Spheniscus mendiculus	Galapagos penguin	USFWS	Endangered	Oceanic Islands
Oceanodroma castro	Band-rumped storm petrel	USFWS	Critical	Oceanic Islands
Pterodroma phaeopygia	Dark-rumped petrel	IUCN	Critically endangered	Oceanic Islands
Buteo galapagoensis	Galapagos hawk	USFWS, IUCN	Vulnerable	Oceanic Islands
Phalacrocorax harrisi	Flightless cormorant	IUCN	Endangered	Oceanic Islands
Nesomimus trifasciatus	Floreana mockingbird (Charles mockingbird)	IUCN	Endangered	Oceanic Islands
Laterallus spilonotus	Galapagos Rail	IUCN	Vulnerable	Oceanic Islands
Larus fuliginosus	Lava gull	IUCN	Vulnerable	Oceanic Islands
Camarhynchus pauper	Medium tree-finch	IUCN	Vulnerable	Oceanic Islands
Camarhynchus heliobates	Mangrove finch	IUCN	Critically endangered	Oceanic Islands

Scientific Name	Common Name	Listing Agency/ Organization	Current Listing Status	Occurrence Within Study Area
Coccyzus ferrugineus	Cocos Island cuckoo	IUCN	Vulnerable	Oceanic Islands
Nesotriccus ridgwayi	Cocos Island flycatcher	IUCN	Vulnerable	Oceanic Islands
Pinaroloxias inornata	Cocos Island finch	IUCN	Vulnerable	Oceanic Islands

* For an explanation of listing status categories, see Appendix F.

Note: This table includes current threatened and endangered species listing information from the IUCN database (http://www.redlist.org/programme.html). The species list and listing categories were adopted by IUCN Council effective January 2001. This list includes listed species of reptiles, birds, and mammals that occur on the Galapagos Islands, Cocos Island, and Malpelo Island, and in the surrounding oceanic environment. This list does not include mainland- or coastal- Ecuador species. The IUCN lists over 150 total species for the Galapagos Islands, Cocos Island, and Malpelo Island.

3.2.1.7 Commerce

The equatorial Pacific is used by both commercial shipping and fishing vessels and is overflown by aircraft. These commercial uses of the open ocean portion of the affected environment are discussed below.

Shipping

In terms of commercial shipping, Figure 3-5 shows a sea-lane chart that identifies the affected environment. The area is primarily used as a shipping route for vessels from or to the Panama Canal and ports along the Pacific coast of the United States, Hawaii, Tahiti, and South America, including Callao (Ecuador) and Iquique (Chile).

It is difficult to estimate potential shipping traffic on any given day. Shipping data from the Panama Canal are useful in assessing the relative magnitude of traffic in the overflight area. The Panama Canal is designed to handle 50 ships per day, the maximum number of daily transits was 65.[1] In 1998 there was an average of 35.7 daily transits.[2] The U.S. Gulf/East Coast to Asia and Europe to the West Coast of the United States and Canada are the major trade routes using the Panama Canal. These shipping routes are downrange of launches using the extreme lower azimuths (i.e., 83^{o} to 84^{o}). Table 3-3 lists the Panama Canal shipping routes and tonnage that routinely pass through the affected environment. Approximately 26 percent of the total tonnage shipped through the Panama Canal uses routes downrange of the launch. Some other route categories — such as "round the world" (at 20,250 thousand tons) and "all other routes, not otherwise classified" (at 17,621 thousand tons), which total an additional 17 percent of the tonnage shipped through the Panama Canal — may also pass through the affected environment. Therefore, using tons shipped as a surrogate for vessel traffic — 26 to 43 percent of Panama Canal traffic, or 10 to 17 vessels per day (26 to 43 percent of 40 daily transits) — may be in transit through the affected environment in route to or from the Panama Canal.

TABLE 3-3. PANAMA CANAL SHIPPING TRAFFIC

Panama Canal Traffic by Route	Tons ('000s)
East Coast U.S. – West Coast South America	21,711
East Coast U.S./Canada – Oceania	5,157
Europe – West Coast South America	16,518
Europe – Oceania	2,653
South America Intracoastal	6,709
West Indies – West Coast South America	3,053
TOTAL	55,801

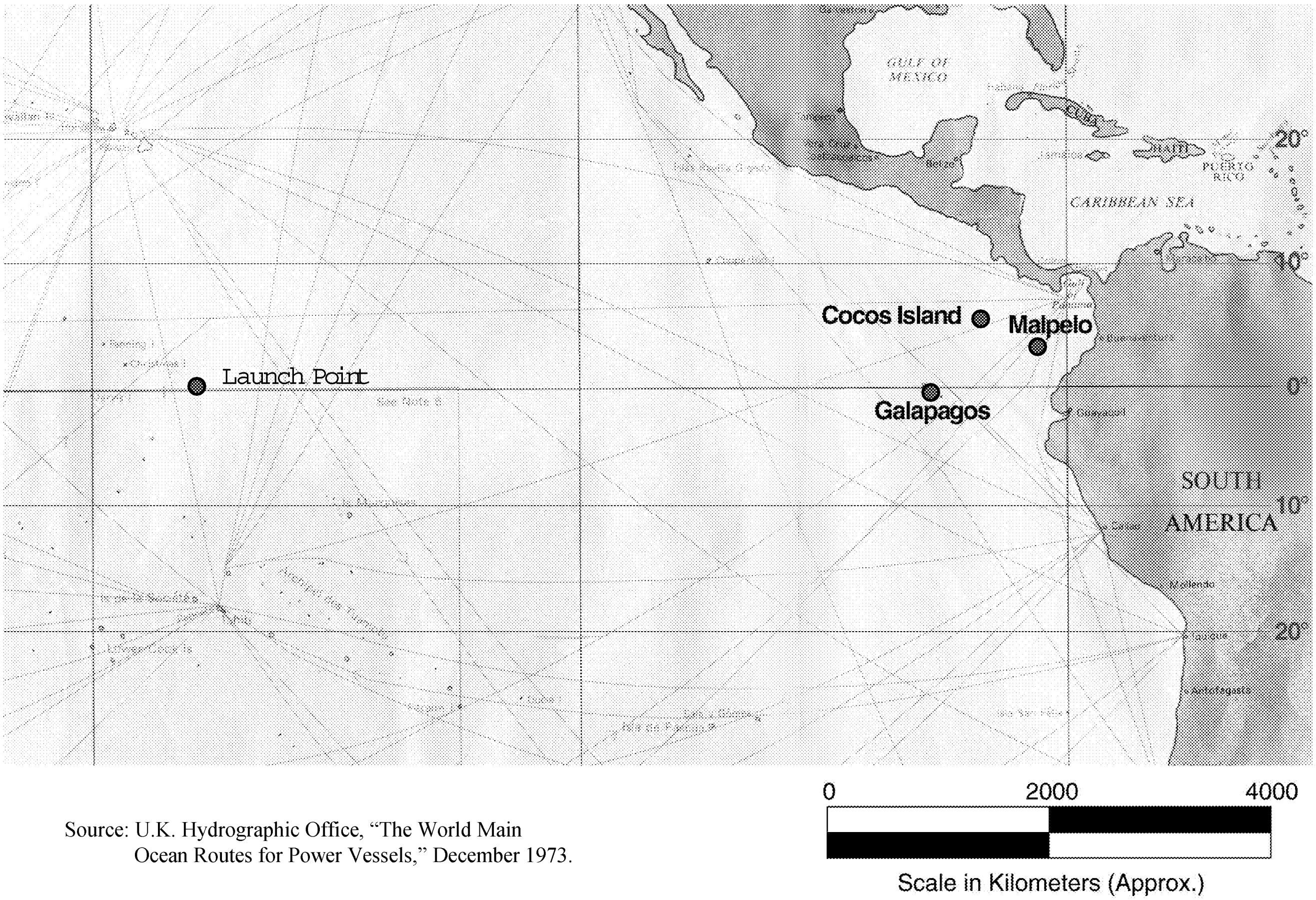
Source: http://www.orbi.net/pancanal/proposal/htraffic.htm

Commercial Fishing

Commercial fishing occurs within the affected environment, primarily by national fleets operating within their EEZs and territorial waters or by land-based foreign fleets operating under a license

[1] http://www.eia.doe.gov/emeu/cabs/panama.html
[2] http://www.eia.doe.gov/emeu/cabs/panama.html

Figure 3-5
Shipping Lanes of Equatorial Pacific Ocean



Source: U.K. Hydrographic Office, "The World Main Ocean Routes for Power Vessels," December 1973.

or fisheries agreement with a coastal nation. Within the affected environment, commercial fishing is most active south of the equator in the area influenced by the South Equatorial Current, which generates cold, nutrient-rich upwellings. These waters sustain the Peruvian anchoveta (*Engrautis ringens*) fishery, which is the largest single species fishery in the world (Food and Agriculture Organization (FAO), 1997). The area north of the equator, off the coast of northern Ecuador and Colombia, is affected by the North Equatorial Current, which has a relatively low productivity compared to the upwelling areas to the south. Commercial fisheries in this area include shrimp, small coastal pelagic species (i.e., herring), and large tropical migratory species such as yellow fin tuna (*Thunnus albacares*) and eastern Pacific bonito (*Sarda chiliensis*).

This area has experienced large fluctuations in fish production and major shifts in species composition over the past several decades. Much of this variability in abundance and composition is caused by changing environmental conditions, such as El Niño, that affect nutrient-bearing currents.

Based on overly-optimistic perceptions of fish abundance during productive years, fisheries expanded rapidly and catches exceeded sustainable levels, which contributed to major population declines (FAO, 1997). The collapse in fishery populations presents social and economic implications at the national, regional, and international levels. The southeast Pacific fishing industry is a major contributor to world fish production (accounting for almost 22 percent of the 1994 world marine fish production) (FAO, 1997). Most of the commercial fishery species in the region are considered to be fully to overly exploited (FAO, 1997).

Commercial fisheries are concentrated along the relatively narrow (maximum width 120 km or 75 mi) (FAO, 1997) continental shelf along the Pacific coast of South America. Areas suitable for bottom trawling are found off the coasts of Ecuador and northern Peru. As fishery stocks have become depleted closer to the South American coast, commercial fishing pressures have increased around the Oceanic Islands. In the 1980s, the lobster population was over exploited to the extent that the entire fishery was closed for two years, during which time there was a significant increase in the sea cucumber (*Sticopus fuscus*) harvest.

Some purse seining for tuna and long-lining for tuna, billfish, and shark occurs in and around the Galapagos. Ecuador's Congress passed the Special Law of Galapagos in 1998, and approved the Galapagos Marine Reserve Management Plan in 1999, both of which prohibit commercial fishing within 65 km (40 mi) of the coast of the Galapagos Islands. However, the constitutionality of the law is being challenged, and commercial fishing has not significantly decreased (Charles Darwin Research Station (CDRS), 2000).

Cocos Island is located in the less productive north ecoregion and is not subject to the same fishing pressures as the Galapagos Islands. Nevertheless, the Costa Rican Government has included the marine ecosystems up to a distance of 15 km (9 mi) around the island as part of a national park. The entire area was declared a zone of "absolute protection," where extraction of marine resources is banned (UNESCO, 2000). Although some commercial fishing traffic enters the 15-km (9-mi) zone, park rangers patrol the area.

Commercial fishing around Malpelo Island is limited. It has no specified zones for protection of marine ecosystems.

Commercial Air Traffic

The FAA National Ocean Service maps of commercial airline flight paths over the Pacific Ocean (Figure 3-6) indicate that four major air routes, from Los Angeles and San Francisco and one route from Hawaii, cross the affected environment. These major air routes intersect potential SLLP flight paths close to the launch site (all west of approximately 135° W longitude). East of 135° W longitude, which includes the majority of the airspace within the affected environment, is categorized as uncontrolled. This area includes potential SLLP flight paths over the open ocean and Oceanic Islands.

3.2.2 Oceanic Islands

The Oceanic Islands occurring within the overflight zone of the proposed project include the Galapagos Islands, Cocos Island, and Malpelo Island. This section provides an overview of the geology, atmospheric processes, biological communities, and social and economic conditions of these Oceanic Islands. The proposed project does not affect other aspects of the environment, such as noise and visual resources because the launch vehicle would not be audible or visible at the islands.

The Galapagos Islands (Figure 3-7) consist of 120 islands, rocks, and islets in the eastern Pacific Ocean, with a total land area of about 8,000 km^2 (3,100 mi^2). The Galapagos are a province of the Republic of Ecuador and are located 1,000 km (625 mi) west of the mainland. Cocos Island is located approximately 500 km (312 mi) west of the Pacific coast of Costa Rica. It is approximately 2 km (1.2 mi) long and 1 km (0.6 mi) wide (Figure 3-8). Cocos Island is governed by Costa Rica and is protected as a national park. Malpelo Island lies approximately 450 km (281 mi) west of Colombia in the equatorial Pacific Ocean. It is approximately 2.2 km (1.4 mi) long and 0.8 km (0.5 mi) wide. Malpelo Island is governed by Colombia (Figure 3-9).

3.2.2.1 Geology

As with most islands in the equatorial Pacific, the three Oceanic Island groups are volcanic in origin. These islands, many of which are the summits of volcanoes, are the product of mantle plumes (molten rock) that have risen from the Earth's interior (Steadman, 1988). These volcanoes formed under the sea and then broke through the ocean floor, growing in size and eventually emerging from the surface of the water to become islands. The Galapagos Islands rise from the Galapagos Platform, located at the intersection of the Cocos and Carnegie submarine ridges (Wooster and Hedgpeth, 1966). Cocos Ridge extends northeastward toward Costa Rica, with a depth of less than 2,200 m (6,600 ft); and Carnegie Ridge extends eastward to Ecuador and Peru, with a depth of less than 2,600 m (7,800 ft; see Figure 3-3). Cocos Island is the only portion of the Cocos Ridge to appear above sea level. Malpelo Island, located between the Cocos and Carnegie Ridges, rises from the Malpelo Ridge (Meschede, 1998).

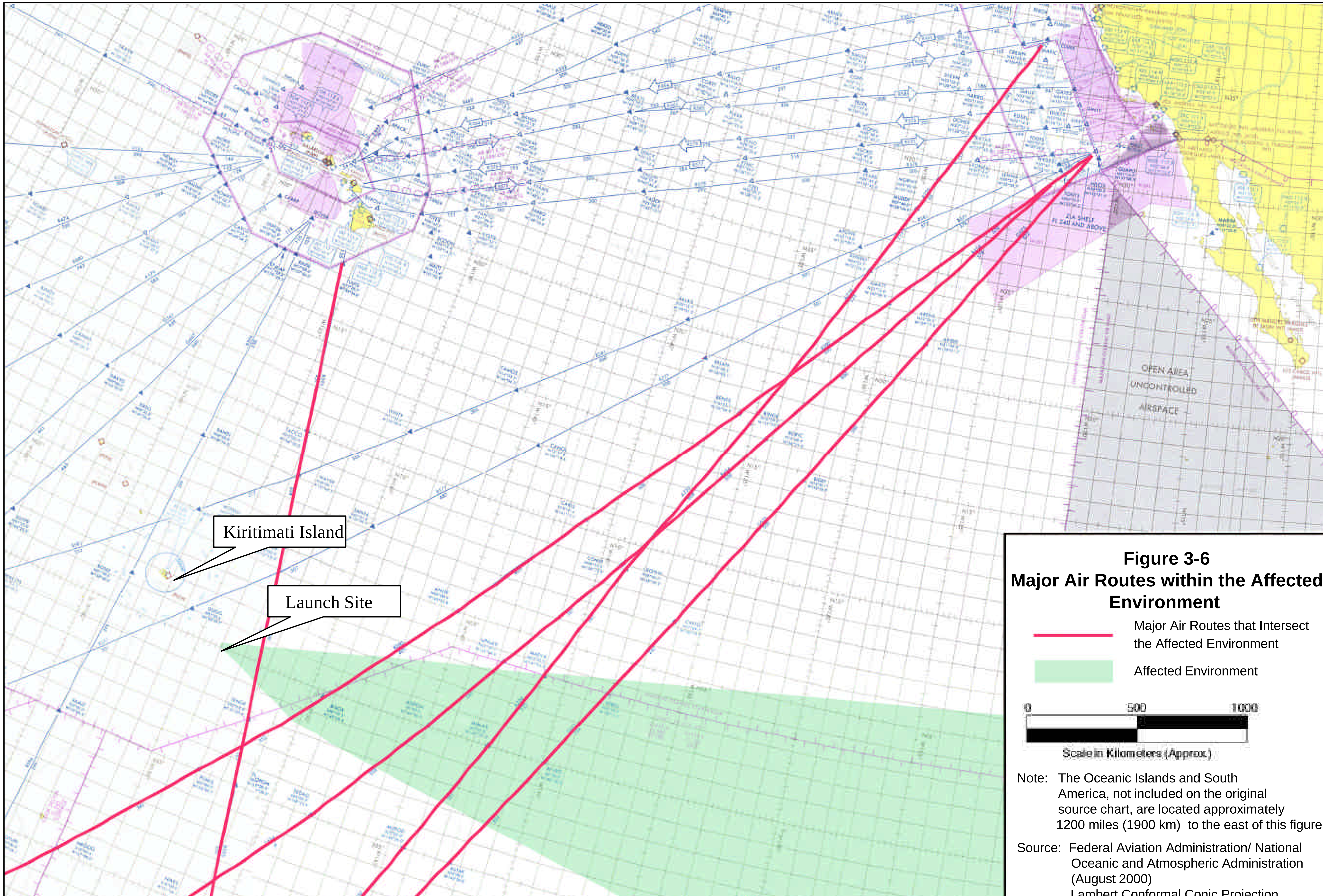
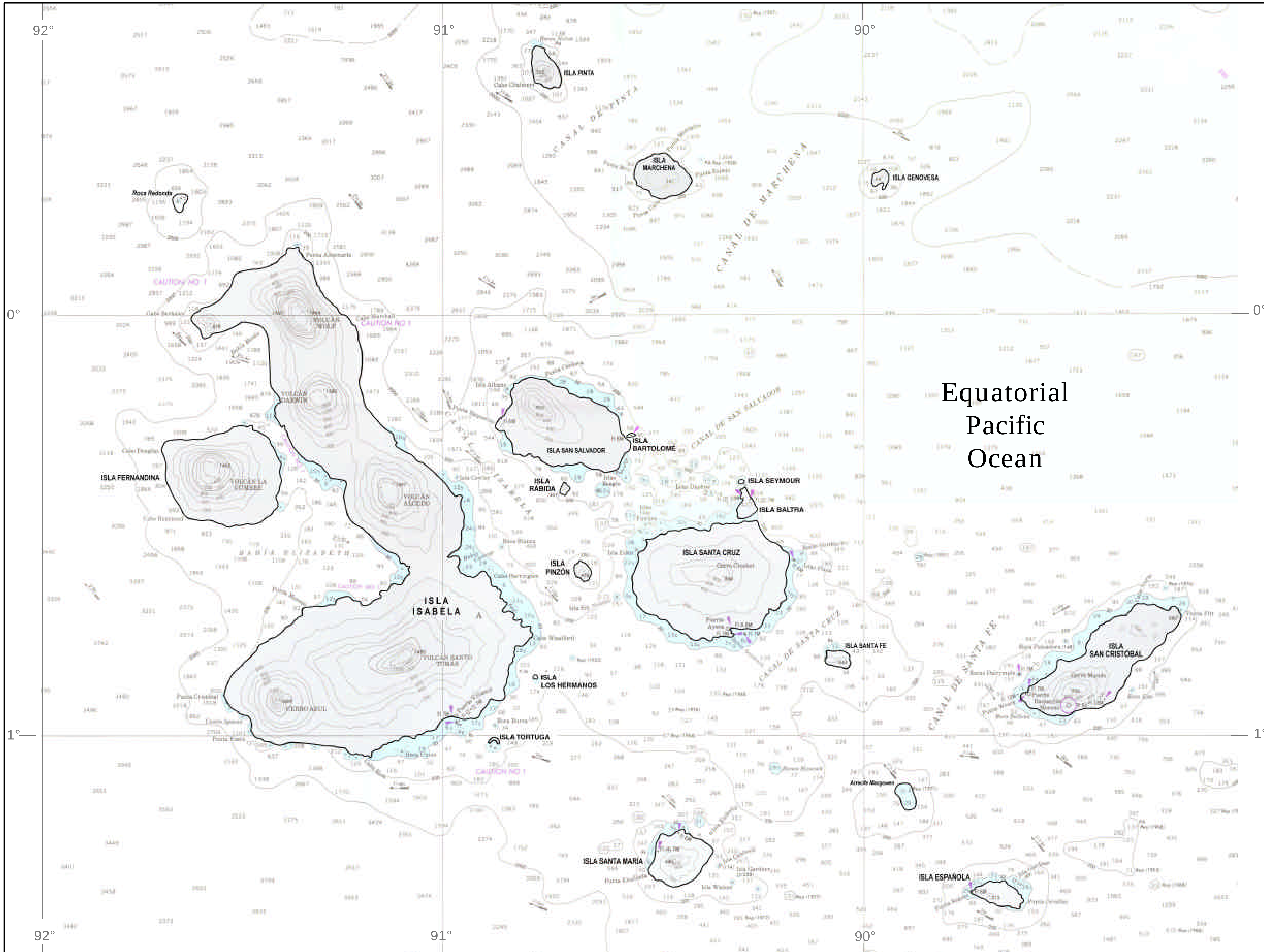


Figure 3-6
Major Air Routes within the Affected Environment

Note: The Oceanic Islands and South America, not included on the original source chart, are located approximately 1200 miles (1900 km) to the east of this figure.

Source: Federal Aviation Administration/ National Oceanic and Atmospheric Administration (August 2000)
Lambert Conformal Conic Projection

Figure 3-7
Galapagos Islands and Surrounding Waters



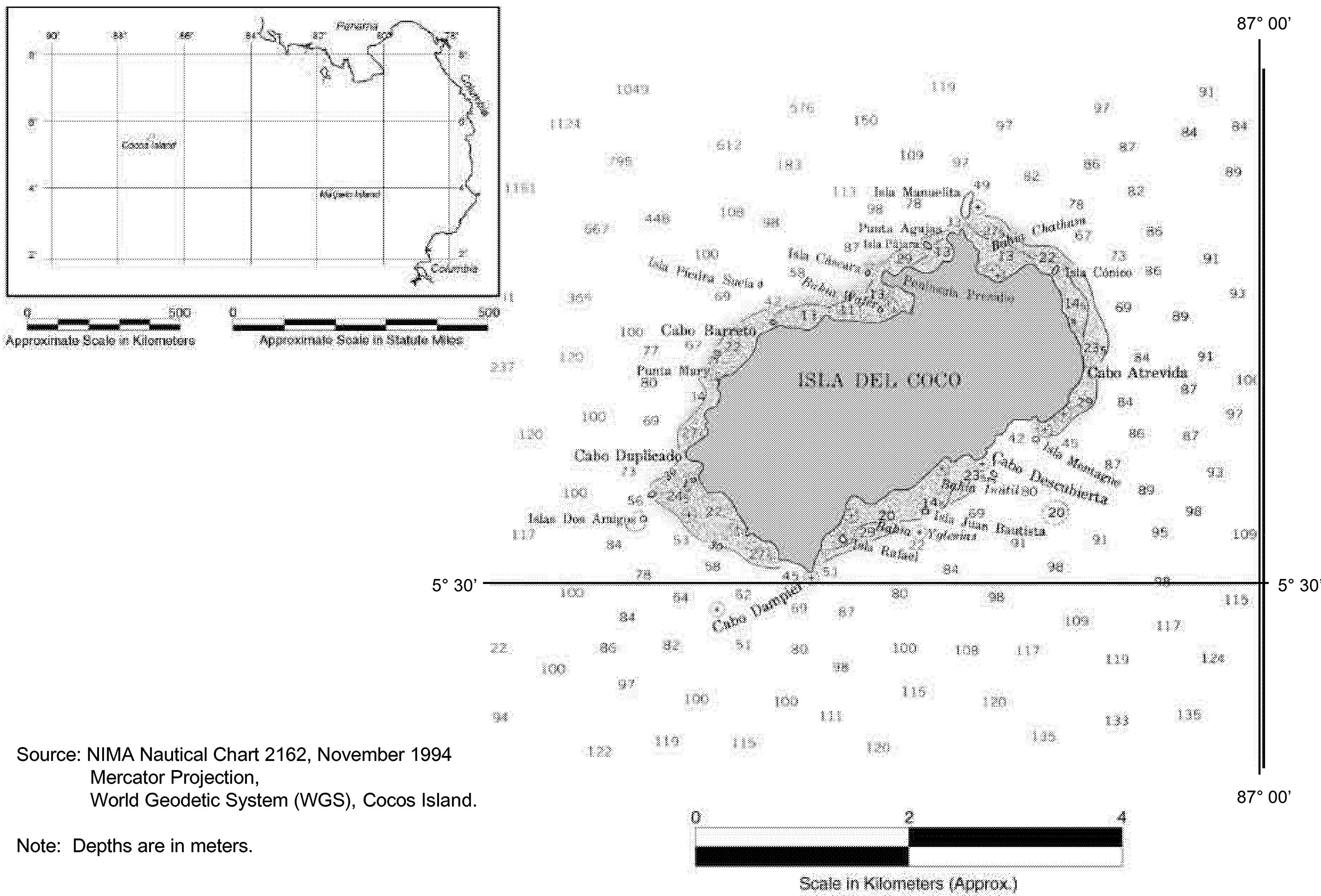
Source: Mercator Projection, World Geodetic System (WGS), Galapagos Islands.

Note: Depths and elevations are in meters.

0 30 60

Scale in Kilometers (Approx.)

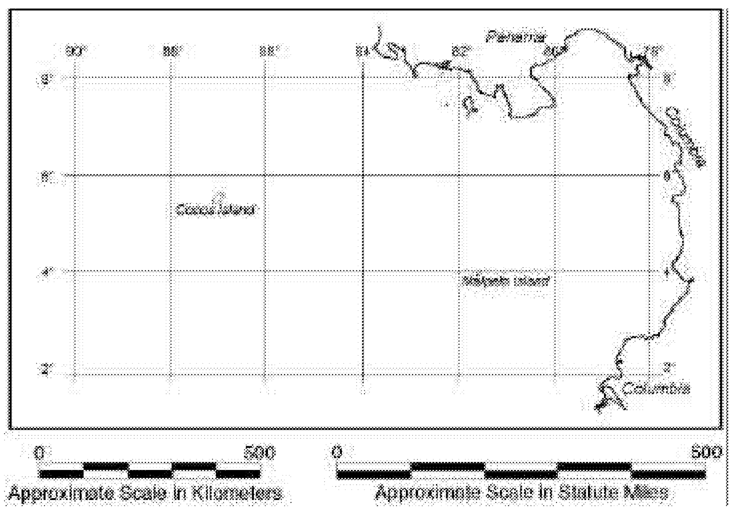
Figure 3-8
Cocos Island and Surrounding Waters

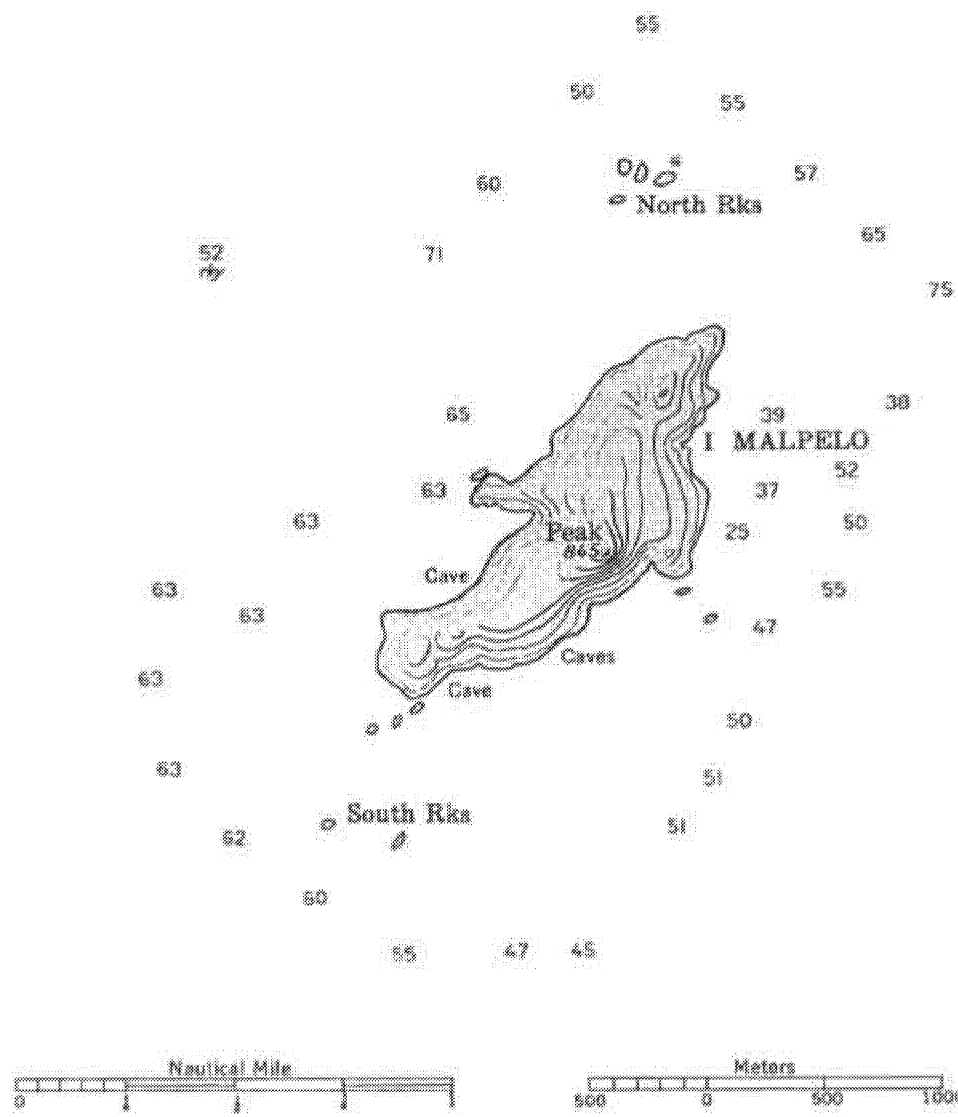


Source: NIMA Nautical Chart 2162, November 1994
Mercator Projection,
World Geodetic System (WGS), Cocos Island.

Note: Depths are in meters.

Figure 3-9
Malpelo Island and Surrounding Waters





Source: NIMA Nautical Chart 2162, November 1994

Peak, Lat. 3 59’ 07” N., Long. 81 35’ 40” W.

Note: Depths are in fathoms.

Galapagos Islands

Typical landscape features of the Galapagos Islands include crater lakes, fumaroles, lava tubes, sulfur fields, and a variety of lava and other volcanic materials such as pumice, ash, and tuff. As a result of their volcanic origin, the Galapagos Islands are composed almost exclusively of basalt. In geological terms, the Galapagos Islands are young, with the oldest islands being roughly three to four million years old (Williams, 1966). The larger islands typically consist of one or more sloping shield volcanoes, culminating in collapsed craters or calderas.

Minor volcanic eruptions and earthquakes are common in the Galapagos Islands. During the last 200 years, over 50 eruptions have been recorded from eight of the Galapagos volcanoes (Goff et al., 1999). The volcanoes are classified as shield volcanoes; they typically measure from 15 to 30 km (9.4 to 18.7 mi) across the base, with slopes gradually becoming steep upward to the rims of deep summit calderas with terraced walls (Wallace, 1966). The most active volcanoes are Fernandina and Isabela, the highest and westernmost islands in the Galapagos (Williams, 1966). The most recent eruptions occurred on Fernandina in 1995 and on Isabela in 1998. The least active volcanoes, and possibly the oldest, are Santa Maria, Espanola, and San Cristobal, the southeasternmost islands in the Galapagos.

Cocos Island

Cocos Island is approximately 2 km (1.2 mi) long and 1 km (0.6 mi) wide. It is located at the center of the volcanic Cocos Ridge, which runs from the Galapagos Islands to the Middle American Trench, southeast of Costa Rica. The island consists of basaltic rock and tuffacious breaches affected by trachytic intrusions. The jagged coast is lined with underwater caves and cliffs as high as 183 m (600 ft). The underwater profile consists of stepwise shelves with almost no intertidal zone and a shallow submerged fringing reef, which culminates in sand and rubble at the edge of a trench that is several hundred meters deep.

Malpelo Island

Malpelo Island is volcanic in origin. The present island is the remnant of a larger geologic structure. Malpelo is approximately 2.2 km (1.4 mi) long and 0.8 km (0.5 mi) wide and reaches a maximum height of 845 m (2,790 ft) above sea level. Wave action has eroded the island and formed steep cliffs (typically ranging from 60 to 230 m [200 to 760 ft] above sea level) and sea caves along its shoreline (Stead, 1975). Several types of igneous rocks are present on Malpelo Island, including dacite, trachyte, tuff, basalt, and andesite. Up to an elevation of 210 to 240 m (690 to 790 ft), the island is mostly trachyte, with lesser amounts of dacite and tuff. The higher elevations are covered by an andesite cap. Soil is scarce on the island and is completely absent at elevations below 90 m (300 ft) due to steep slopes and severe wave action (Stead, 1975).

3.2.2.2 Atmospheric Processes and Conditions

Atmospheric conditions and processes are the same as described in Section 3.4 of the February 11, 1999 EA and are incorporated by reference. (See Appendix A.)

3.2.2.3 Biological Communities

The three Oceanic Island groups lie at the convergence of several major ocean current systems of the equatorial Pacific (see Section 3.2.1.3). This location explains the variety of marine life and a climate that is classified as subtropical even though the islands are located near the equator. Table 3-4 provides information on the 22 primary islands within the three island groups. This section describes the terrestrial biological communities of the Galapagos, Cocos, and Malpelo islands.

Galapagos

Ecuador designated 97 percent of the land area of the Galapagos as a national park in 1959. In 1986, the Galapagos Marine Resources Reserve was established to protect the waters around the archipelago. The UNESCO recognized the Galapagos Islands as a Man and Biosphere Reserve and as a World Heritage Site. Ecuador manages the islands through the Galapagos National Park Service. The Charles Darwin Research Station (CDRS), which is operated by the Charles Darwin Foundation (CDF), carries out scientific research and assists the park service in managing the islands.

Table 3-4 lists terrestrial biological communities for 20 of the 120 Galapagos Islands. These 20 islands contain significant or unique biological communities. The remaining 100 islands are rocky projections that primarily support only nearshore algal communities or are only transiently used by fauna.

Approximately 625 species and subspecies of plants are native to the Galapagos Islands, of which 36 percent (225 species) are endemic. An additional 250 nonnative plant species have been introduced by human inhabitants. Vegetation can be divided into six zones, which are limited by elevation, moisture, and level of soil development (Schofield, 1984):

1) The Littoral Zone consists of Mangrove swamps of *Rhizophora mangle*, *Avicennia germinans*, and *Sesuvium sp.*

2) The Dry Zone is the most abundant habitat in the Galapagos Islands. It is located immediately inland from the coastal zone. Principal species characteristic of this zone are the cacti *Brachycereus sp*., *Jasminocerus thouarsii*, *Opuntia sp*., and *Croton scouleri*. These species represent the only type of vegetation present on small islands of low elevation.

3) The Transition Zone consists of mixed shrub and forested habitat. A characteristic species is the palo santo tree (*Bursera sp.*).

4) The Scalesia Zone — similar to wet tropical forest — is dominated by *Scalesia sp*. and *Pisonia floribunda*.

TABLE 3-4. CHARACTERISTICS OF OCEANIC ISLANDS

Island	Location	Primary Habitats and Significant Natural Features	Characteristic Species	Major Human Activities
Galapagos Islands				
Pinta	0.55°N 90.75°W	Summit is 850 m (2,800 ft) above sea level and has no caldera. Island is characterized by young lavas and cinder cones. Introduction of goats to the island caused much ecological damage, and vegetation is sparse.	Once had a large tortoise population that was decimated by fishermen. One Pinta tortoise remains and is the last known individual of this species.	Uninhabited
Isabela	0.60°S 91.15°W	Largest island in the Galapagos, accounting for half of the total land mass. Has five active volcanoes and Darwin's Salt Lake Crater.	Flightless cormorant, Galapagos penguin, blue-footed booby, masked booby, marine turtles, sea lions.	Inhabited Cattle herding (300 head)
Santa Fè	0.95°S 90.12°W	Oldest island in the Galapagos. Has a sheltered bay, steep cliffs, and an area of Opuntia cactus. Eroded volcanic cones called "cerros" mark the youngest parts of the island. Other features include spatter cones, pit craters, and small calderas.	Sea lion, Galapagos white-tipped shark, marine turtle, Galapagos hawk, frigatebird, pelican, swallow-tailed gull, mockingbird.	Uninhabited Visited by tourists
Bartolomè	0.25°S 90.50°W	Evokes a lunar landscape of cones and craters. Stark and dry, only the occasional prickly pear, lava cactus, or Scalesia bush. Lies opposite of Sullivan Bay. Pinnacle Rock is one of the best known landmarks of this island.	No information available.	Uninhabited
Marchena	0.33°N 90.50°W	With Pinta and Genovesa, Marchena forms the northern trio of islands just above the equator. A large shield volcano of which only the upper 343 m (1,130 ft) is above sea level.	Southern Martin, small tree finch, large tree finch, Marchena lava lizard	Uninhabited Marchena is closed to tourists; however, divers frequent the surrounding waters.

Island	Location	Primary Habitats and Significant Natural Features	Characteristic Species	Major Human Activities
Santa Maria	1.25°S 90.45°W	Beach, enclosed lagoon, forest. The terrain rises and falls in proliferation of volcanic cones. The western part of the island consists of bare lava flows and a black sand beach. In the northeastern portion of the island is Punta Cormorant's lagoon. An imploded volcano, Devil's Crown, lies just off the coast of the main island.	Sea lion, marine turtle, ghost and sally lightfoot crabs. Flamingo and several other bird species feed in the lagoons and ponds.	Inhabited The first inhabited island of the Galapagos (since 1807). Cattle farming (300 head).
San Cristobal	0.80°S 89.45°W	Home to the capital and administrative center of the Galapagos Islands, Puerto Baquerizo Moreno. Provides habitat for five endemic species (three reptiles, two birds)	Tuberculated leaf-toed gecko, San Cristóbal leaf-toed gecko, San Cristóbal lava lizard, San Cristóbal snake, red bat, paint-billed crake, Galápagos barn owl, San Cristóbal vermilion flycatcher, San Cristóbal mockingbird, vegetarian finch.	Inhabited Airport located on the island. Puerto Baquerizo Moreno is the oldest settlement in the Galapagos.
Culpepper	1.65°N 92.00°W	Encircling reef extends 400 m (0.25 mi).	Largest breeding colony of sooty tern in the Galapagos, large cactus finch.	Uninhabited Inaccessible due to absence of landing areas. Protected as a natural area by the Ecuador Government.
Daphne Major/Minor	0.40°S 90.35°W	Sparsely vegetated by herbaceous and shrub vegetation. Two small craters host thousands of nesting blue-footed boobies. Consists of 3 islets.	Swallow-tailed gull, brown noddy, blue-footed booby, masked booby, red-billed tropicbird	Uninhabited
Pinzon	0.70°S 90.70°W	18-km^2 (7 mi^2), 458-m (1,510 ft) volcano peak, entirely cliff bound. Provides habitat for one endemic reptile species.	Pinzón lava lizard, Slevin's snake.	Uninhabited

Island	Location	Primary Habitats and Significant Natural Features	Characteristic Species	Major Human Activities
Espanola	1.45°S 89.67°W	Punta Suarez has 30-m (100 ft) high cliffs that provide nesting habitat for many seabird species. Gardner Bay provides feeding habitat for many bird species and beach habitat for sea lions and marine iguanas. Encircling reefs extend 400 m (0.25 mi).	Masked booby, blue-footed booby, Galapagos dove, hooded mockingbird, cactus finch, warbler finch, waved albatross, sea lion, marine iguana, lava lizard.	Uninhabited One of the most visited islands due the variety of animals. Landing point is Punta Suarez.
Santa Cruz	0.60°S 90.35°W	The central island in the Galapagos and home to the main port, Puerto Ayora, and the Charles Darwin Research Station. Highly diverse flora and fauna. Mangrove forest, arid forest dominated by polo santo trees and prickly pears, Miconia shrubland. Tortoise reserve at Parte Alta twin craters. The island's peak is at 900 m (2,970 ft) above sea level. Cow pastures and small plantations in the island interior.	Galapagos tortoise, red bat, lava lizard, mockingbird, ground finch, vermilion flycatcher.	Inhabited Puerto Ayora, the largest town in the Galapagos, is the main tourist destination in the islands.
San Salvador	0.25°S 90.75°W	The shoreline of Perto Egas characterized by cliffs of hard volcanic ash. Primary habitat is polo santo forest. Feral goats have consumed most of the vegetation, turning much of the land into an open savannah. A salt crater, Sugarloaf volcano (390 m or 1,290 ft), is located in James Bay. Sullivan Bay is known for its conical volcano.	Fur seal, flamingo, masked booby, pelican, feral goat.	Uninhabited Commercial attempts to extract minerals from the salt lake crater failed. Today, only a few roads and abandoned buildings remain.
Rabida	0.42°S 90.72°W	A small island 2 km (1.2 mi) in width and 400 m (0.25 mi) at its highest point. Known for its unusual red-colored beaches. Vegetation consists of Opuntia cactus, polo santo trees, and shrubland.	Sea lion outhaul area, flamingo, penguin. Nine of 13 species of finch occur here.	Uninhabited Visited by tourists
Wenman	1.38°N 91.82°W	Rocky, barren island.	Seabird nesting area.	Uninhabited Inaccessible due to the absence of landing sites.

Island	Location	Primary Habitats and Significant Natural Features	Characteristic Species	Major Human Activities
Fernandina	0.35°S 91.55°W	The westernmost island of the Galapagos and one of the most volcanically active. One of the newest of the Galapagos volcanoes, evident by the lack of erosion and bareness of vegetation. Young mangrove forest is the primary habitat. Rocky shores, black sand beaches, and frequent volcanic upheavals. The main volcano is 1,500 m (4,950 ft) high with a diameter of 6.5 km (4 mi), depth of 800 m (2,640 ft), and a 910 m (3,000 ft) deep caldera.	Heron, yellow warbler, pelican, frigatebird, mangrove finch, petrel, shearwater, Galapagos penguin, fur seal, flightless cormorant, vegetarian finch, sharp-beaked ground finch, Galápagos barn owl, black rail, large Fernandina rice rat, Slevin's snake, Galápagos lava lizard, Galapagos leaf-toed gecko. Feral goats and rats.	Inhabited Visited by tourists; landing point is called Punta Espinosa.
Seymour	0.40°S 90.25°W	No information available.	Known for its large nesting colony of great and magnificent frigatebirds. The blue footed booby, land iguana, swallow-tailed gull, pelican, and red-billed tropicbird also nest here.	Uninhabited
Plaza Sur	0.60°S 90.10°W	Smallest of the 13 large islands. Dry sandy land.	Sea lion, land iguana, marine iguana.	Uninhabited Visited by tourists
Baltra	0.45°S 90.25°W	Approximately 100 m (330 ft) above sea level.	Land iguana, marine iguana, marine turtle.	Inhabited Airport located on the island
Genovesa	0.35°N 89.97°W	A small island (10 km^2, or 3.9 mi^2) in the shape of a horseshoe. One of the most pristine islands of the Galapagos group. Polo santo trees on the cliffs are a major breeding site for water and land birds. The island's interior, Darwin Bay, an imploded volcano, is the dominant natural feature. Encircling reefs are present.	Important breeding site for marine, land, and water birds, including red-footed booby, masked booby, frigatebird, wandering tattler, turnstone, whimbrel, lava gull, yellow-crowned heron, lava heron, black-crowned night heron, finch, Galapagos mockingbird, and Galapagos dove. One reptile species, a subspecies of marine iguana.	Uninhabited Visited by tourists (particularly birders).

Island	Location	Primary Habitats and Significant Natural Features	Characteristic Species	Major Human Activities
Cocos Island				
	5.55°N 87.00°W	Coastline is irregular, with cliffs rising almost vertically to 200 m (660 ft). Inland terrain is mountainous with numerous rivers and streams. Primary habitats include a herbaceous zone and a montane cloud forest zone. Two bays (Bahi`a Wafer and Bahi`a Chatham). Largest watercourses are the Genio and Pittier Rivers. Highest peak (Cerro Iglesias) is 634 m (2,090 ft).	High numbers of endemic plant and animal species. 87 bird species have been recorded, including 3 endemic (Cocos Island cuckoo, Cocos Island flycathcer, and Cocos Island finch); 2 endemic reptiles (Anolis lizard and gecko). Feral pigs, goats, and cats are the only terrestrial mammals.	The Government of Costa Rica took official possession of Cocos in 1869. After two unsuccessful attempts to colonize the island, it has remained free of permanent human intervention except for 10-15 resident park rangers.
Malpelo Island				
	4.00°N 81.58°W	400 m (1,320 ft) long and 545 m (1,800 ft) wide. Highest peak is 350 m (1,150 ft) above sea level. Flora limited to lichens and fern.	Anolis and anguid lizards, 10 species of birds. Masked booby and swallow-tailed gull nesting site. Large migrations of hammerhead and whale sharks occur just offshore.	Island has fewer than 10 Colombian Coast Guard employees; otherwise, it is uninhabited. Colombia has nearly completed the processes for designating Malpelo as a nature reserve.

Source: United Nations Environmental Program, UN System-Wide Earthwatch Web Site; WCMC, 2000; Gorman and Chorba, 1985; Wolda, 1985; Slud, 1967.

5) The Miconia Zone commonly referred to as the shrub zone — is found primarily on Santa Cruz. It is characterized by dense, monotypic stands of cacaotillo shrubs (*Miconia robinsoniana*).
6) The Fern-Sedge Zone covers the summit areas of the larger islands, where moisture is retained in temporary pools and Sphagnum moss. Endemic tree ferns (*Cyathea weatherbyana*) and various grass and sedge species occupy collapsed lava tubes and other small potholes.

Because the Galapagos Islands have always been separated from the mainland, the plants that occur there arrived by long distance dispersal. Most of the plant species were derived from South America, with some from Mexico and Central America (Schofield, 1984). Historically, birds are believed to be the major source of plant dispersal in the Galapagos, with wind and ocean currents having a minor influence. In modern times, humans have introduced approximately 250 plant species to the Galapagos Islands (Schofield, 1984). Several of these introduced plants have dramatically changed the landscape of the islands. Large areas of all of the inhabited islands have been invaded by guayaba (*Psidium guajava)* and elephant grass (*Pennisetum sp*.), which, in many areas, have completely replaced native vegetation. Orange and lemon trees are widespread in the Scalesia zones of San Cristobal and Santa Maria, often excluding the native *Scalesia* and *Pisonia* species.

Table 3-5 provides information on the common reptiles and birds that occur on the Galapagos Islands. Except for two species of marine tortoises, all of the reptile species are endemic. These include the Galapagos giant tortoise (*Geochelone)*, with 11 subspecies on different islands; two species of land iguanas; one species of marine iguana; three species of snakes; and several species of *Tropidurus* lizards and *Phyllodactilus* geckos. The native avifauna includes 57 residents, of which 26 (46 percent) are endemic and 31 are regular migrants. Endemic bird species include 13 species of finch (collectively known as Darwin's finches), eight species of seabirds, and five species of land birds. Six indigenous mammal species are found on the islands: the Galapagos fur seal, Galapagos sea lion, two species of rice rat, and two species of bat. There are roughly 1,000 insect species, 50 spiders, and 60 land snail species documented in the region, some of which are endemic to individual islands (WCMC, 2000). Sally lightfoot crab (*Graspus graspus)* is a characteristic shoreline species on all islands within the Galapagos.

Cocos Island

Although Cocos Island has a less diverse flora than that of the Galapagos Islands, it has a similar percentage of endemic species [35 percent (70 species) of vascular plants compared with 36 percent on the Galapagos]. The flora of Cocos Island consists of 235 vascular and 137 nonvascular plants (Fournier, 1966). Two plant zones are found on the island (Gomez, 1975):

- A coastal, mostly herbaceous, Littoral Zone, which rises between 0 to 50 m (0 to 165 ft), with two habitat types: the *Annona glabra* swamp and the firm terrain with various species of flowering plants.
- A montane cloud forest zone (Mountainous Zone), which grows to 100 m (330 ft). The predominant tree species include the endemic species *Huriki sacglottis holdridgei*, *Ocotea insularis*, and *Cecropia pittieri*. Undergrowth in the forest is dense with *Hypolitrum amplum* and several species of ferns (Dauphin, 2000).

TABLE 3-5 COMMON BIRD AND REPTILE SPECIES OF THE GALAPAGOS, COCOS, AND MALPELO ISLANDS

Latin Name	English Name	Distribution	Endemic
Reptiles			
Geochelone elephantopus	Galápagos tortoise (12 subspecies)	All major islands except Genovesa, Marchena, Culpepper, Wenman; extinct on Santa Maria, Santa Fé, Rábida, and perhaps Fernandina.	X
Chelonia mydas agassizii	Green turtle	Widespread throughout the Galapagos (endemic subspecies).	X
Phyllodactylus tuberculosus	Tuberculated leaf-toed gecko	San Cristóbal	X
Phyllodactylus gilberti	Wenman leaf-toed gecko	Wenman	X
Phyllodactylus leei	San Cristóbal leaf-toed gecko	San Cristóbal	X
Phyllodactylus barringtonensis	Santa Fé leaf-toed gecko	Santa Fé	X
Phyllodactylus galapagoensis	Galapagos leaf-toed gecko	Santa Cruz, Daphne Major, San Salvador, Pinzón, Crowley, Tortuga, Isabela, Fernandina	X
Phyllodactylus sp.	Rábida leaf-toed gecko	Rábida	X
Phyllodactylus bauri	Baur's leaf-toed gecko	Española, Gardner near Española, Santa Maria, Gardner near Santa Maria, Enderby, Champion	X
Sphaerodactylus pacificus	Gecko	Cocos	X
Phyllodactylus sp.	Gecko	Malpelo	
Norops townsendi	Anolis lizard	Cocos	X
Anolis agassizi	Anolis lizard	Malpelo	
Celestus hancocki	Anguid lizard	Malpelo	
Tropidurus pacificus	Pinta lava lizard	Pinta	X
Tropidurus duncanensis	Pinzón lava lizard	Pinzón	X
Tropidurus habelii	Marchena lava lizard	Marchena	X
Tropidurus bivittatus	San Cristóbal lava lizard	San Cristóbal	X
Tropidurus delanonis	Española lava lizard	Española, Gardner near Espanola	X
Tropidurus grayii	Floreana lava lizard	Santa Maria, Gardner near Santa Maria, Caldwell, Enderby, Champion	X
Tropidurus albemarlensis	Galápagos lava lizard	Santa Fé, Santa Cruz, San Salvador, Rábida, Isabela, Fernandina	X

Latin Name	English Name	Distribution	Endemic
Conolophus subcristatus	Land iguana	Santa Cruz	X
Conolophus pallidus	Santa Fé land iguana	Santa Fé	X
Amblyrhynchus cristatus	Marine iguana	Throughout the Galapagos on all major islands	X
Alsophis biserialis eibli	San Cristóbal snake	San Cristóbal	X
Alsophis biserialis hoodensis	Española snake	Española, Gardner near Española	X
Alsophis dorsalis dorsalis	Galápagos snake	Santa Fé, Santa Cruz, Baltra, San Salvador, Rábida	X
Alsophis Dorsalis helleri	Isabela snake	Isabela, Tortuga	X
Alsophis dorsalis occidentalis	Fernandina snake	Fernandina	X
Alsophis slevini slevini	Slevin's snake	Pinzón, Isabela, Fernandina	X
Alsophis slevini steindachneri	Steindachner's snake	Santa Cruz, Baltra, San Salvador, Rábida	X
Pelamis platurus	Yellow-bellied sea snake	Widespread throughout Galapagos	X
Seabirds			
Spheniscus mendiculus	Galapagos penguin	Throughout the Galapagos	X
Diomedea leptorhyncha	Waved albatross	Nearly endemic, but also breeds in small numbers on Isla La Plata, off Ecuador.	
Pterodroma phaeopygia phaeopygia	Dark-rumped petrel	Throughout the Galapagos	Endemic subspecies
Puffinus lherminieri subalaris	Audubon's shearwater	Throughout the Galapagos	Endemic subspecies
Oceanites gracilis galapagoensis	White-vented storm petrel	Throughout the Galapagos	Endemic subspecies
Oceanodroma tethys tethys	Wedge-rumped storm petrel	Throughout the Galapagos	Endemic subspecies
Oceanodroma castro	Band-rumped storm Petrel	Throughout the Galapagos	Endemic subspecies
Phaethon aethereus mesonauta	Red-billed tropicbird	Throughout the Galapagos	Endemic subspecies
Pelecanus Occidentalis urinator	Brown pelican	Throughout the Galapagos	Endemic subspecies

Latin Name	English Name	Distribution	Endemic
Sula nebouxii excisa	Blue-footed booby	Throughout the Galapagos	Endemic subspecies
Sula dactylatra granti	Masked booby	Throughout the Galapagos	Endemic subspecies
Sula sula websteri	Red-footed booby	Throughout the Galapagos	Endemic subspecies
Phalacrocorax harrisi	Flightless cormorant	Throughout the Galapagos	X
Fregata minor ridgwayi	Great frigatebird	Throughout the Galapagos, Cocos	X
Fregata magnificens	Magnificent frigatebird	Throughout the Galapagos	X
Haematopus palliatus galapagensis	American oystercatcher	Throughout the Galapagos	Endemic subspecies
Larus fuliginosus	Lava gull	Throughout the Galapagos	X
Larus Furcatus	Swallow-tailed gull	Nearly endemic to Galapagos, but also breeds on Malpelo	X
Sterna fuscata crissalis	Sooty tern	Throughout the Galapagos, large breeding colony on Culpepper	X
Anous stolidus galapagensis	Brown noddy	Throughout the Galapagos	Endemic subspecies
Anous stolidus ridgwayi	Noddy	Malpelo	
Anous minutus diamesus	Black noddy	Malpelo	
Actitis macularia	Spotted sandpiper	Malpelo	
Heteroscelus incanus	Wandering tattler	Malpelo	
Waterbirds			
Ardea herodias cognata	Great blue heron	Throughout the Galapagos	Endemic subspecies
Ardea alba egretta	Great egret	Throughout the Galapagos	Endemic subspecies
Ardeola sundevalli	Lava heron	Throughout the Galapagos	X
Ardeola striata cf. Striata	Striated heron	Throughout the Galapagos	X
Nyctanassa violacea pauper	Yellow-crowned night heron	Throughout the Galapagos	Endemic subspecies
Laterallus jamaicensis spilonotus	Black rail	Santa Cruz, Baltra, San Salvador, Pinta, Isabella, Fernandina	Endemic subspecies
Neocrex erythrops	Paint-billed crake	San Cristóbal, Santa Maria, Santa Cruz, Isabella	Endemic subspecies

Latin Name	English Name	Distribution	Endemic
Gallinula chloropus (cachinnans or pauxilla)	Common gallinule	Throughout the Galapagos	Endemic subspecies
Himantopus himantopus mexicanus	Common stilt	Throughout the Galapagos	Endemic subspecies
Phoenicopterus ruber glyphorhynchus	Greater flamingo	Throughout the Galapagos	Endemic subspecies
Anas bahamensis galapagensis	White-cheeked pintail	Throughout the Galapagos	Endemic subspecies
Land Birds			
Buteo galapagoensis	Galápagos hawk	Throughout the Galapagos, except for Genovesa, Wenman, Culpepper	X
Falco peregrinus	Peregrine falcon	Throughout the Galapagos, Malpelo, Cocos	
Zenaida galapagoensis	Galápagos dove	Throughout the Galapagos	X
Coccyzus melacoryphus	Dark-billed cuckoo	Throughout the Galapagos	X
Tyto punctatissima	Galápagos barn owl	San Cristóbal, Santa Cruz, San Salvador, Isabela, Fernandina	X
Asio flammeus galapagoensis	Short-eared owl	Throughout the Galapagos	Endemic subspecies
Pyrocephalus nanus	Galápagos vermilion flycatcher	Throughout the Galapagos, except for San Cristóbal	X
Pyrocephalus dubius	San Cristóbal vermilion flycatcher	San Cristóbal	X
Myiarchus magnirostris	Large-billed flycatcher	Throughout the Galapagos	X
Progne concolor	Southern Martin	Throughout the Galapagos, except for Genovesa, Marchena, Pinta, Wenman, Culpepper, Malpelo	X
Mimus parvulus	Galápagos mockingbird	Throughout the Galapagos, except for San Cristóbal	X
Mimus melanotis	San Cristóbal mockingbird	San Cristóbal	X
Mimus macdonaldi	Española mockingbird	Española	X
Mimus trifasciatus	Floreana mockingbird	Champion, Gardner near Santa Maria	X
Dendrocia petechia aureola	Yellow warbler	Throughout the Galapagos	X
Geospiza nebulosa	Sharp-beaked ground finch	Santa Maria, Santa Cruz, San Salvador, Isabela, Fernandina, Pinta	X

Latin Name	English Name	Distribution	Endemic
Geospiza fuliginosa	Small ground finch	Throughout the Galapagos, except for Genovesa, Culpepper, Wenman	X
Geospiza fortis	Medium ground finch	Throughout the Galapagos, except for Genovesa, Wenman	X
Geospiza magnirostris	Large ground finch	Throughout the Galapagos, except for Española, Culpepper	X
Geospiza scandens	Small cactus finch	Throughout the Galapagos, except for Española, Fernandina, Genovesa, Culpepper, Wenman	X
Geospiza conirostris	Large cactus finch	Española, Genovesa, Culpepper, Wenman	X
Geospiza crassirostris	Vegetarian finch	San Cristóbal, Santa Maria, Santa Cruz, Isabela, Fernandina, Pinta	X
Geospiza parvula	Small tree finch	Throughout the Galapagos, except for Española, Genovesa, Marchena, Culpepper	X
Geospiza pauper	Medium tree finch	Santa Maria	X
Geospiza psittacula	Large tree finch	Throughout the Galapagos, except for Española, Genovesa, Marchena, Culpepper, Wenman	X
Geospiza pallida	Woodpecker finch	Throughout the Galapagos	X
Geospiza heliobates	Mangrove finch	Isabela, Fernandina	X
Geospiza olivacea	Warbler finch	Throughout the Galapagos	X
Coccyzus ferrugineus	Cocos Island cuckoo	Cocos	X
Nesotriccus ridgwayi	Cocos Island flycatcher	Cocos	X
Pinaroloxias inornata	Cocos Island finch	Cocos	X
Icterus pectoralis	Spot-breasted oriole	Cocos	
Hirundo rustica ethrogaster	Barn swallow	Malpelo	

Source: WCMC, 2000; Steadman and Zousmer, 1988; Gorman and Chorba, 1985; Wolda, 1985; Slud, 1967.

Table 3-5 provides information on the common birds and reptiles that occur on Cocos Island. The fauna on Cocos includes 87 bird species, three of which are endemic species listed as endangered: the Cocos Island cuckoo (*Coccyzus ferrugineus*), Cocos Island flycatcher (*Nesotriccus ridgwayi*), and Cocos Island finch (*Pinaroloxias inornata*; Slud, 1967). Several seabird breeding colonies exist on the surrounding emerged rocks, including the red-footed booby (*Sula sula*), brown booby (*S. leucogaster*), great frigatebird (*Fregata minor*), white tern (*Gingis alba*), and common noddy (*Anous stolidus*). Two species of endemic reptiles are found on the island: the *anolis* lizard (*Norops townsendii*) and a gecko (*Sphaerodactylus pacificus*).

The only terrestrial mammals on the island are introduced pigs, goats, and cats. Over 362 species of insects have been documented on Cocos, including 64 endemic species. The endemic spider (*Wendilgarda galapagensis)* expresses habitat selection and web building behavior that differs from other species of its genus in Central and South America (Eberhard, 1989).

Cocos Island was added to the UNESCO World Heritage List in 1997 and was subsequently designated a Wetland of International Importance (RAMSAR, 1998).

Malpelo Island

Because soil is scarce on Malpelo Island, there are few suitable substrates for plant life. Consequently, plant species are dominated by lichens (71 species) and bryrophytes (113 species), which grow on the island's volcanic surface. The only vascular plant known to occur on Malpelo is a species of fern (*Pityrogramma dealbata*).

Correspondingly, the resident terrestrial faunal diversity of Malpelo Island is low. Ten species of birds are present (three land birds and seven seabirds), two species of lizards (*Anolis agassizi* and *Celestus hancocki*), one species of gecko (*Phyllodactylus sp.*), one land crab (*Gecarcinus malpilensis*), and 37 species of invertebrates (Abele, 1985; Wolda, 1985). Table 3-5 provides information on the common reptiles and birds that occur on Malpelo Island. None of these species are endemic to Malpelo; they are found throughout the equatorial Pacific region. There are no terrestrial mammals on the island. The masked booby (*Sula dactylatra granti*) and swallow-tailed gull (*Creagrus furcatus*) have significant breeding colonies (more than 50 pairs) on the island and its surrounding rocks (Pitman et al, 1995).

3.2.2.4 Social and Economic Conditions

Galapagos Islands

The Galapagos had no aboriginal inhabitants and was discovered in 1535 by Tomas de Berlanga, the Bishop of Panama. During the 17th and 18th centuries, buccaneers used the islands as a staging post, stocking up on water and giant tortoises. During the 19th century, whalers and fur sealers further exploited the islands for ship stores. Ecuador annexed Galapagos in 1832, and small colonies were gradually established on several of the islands (Galapagos Conservation Trust, 2000). In 1959, the Government of Ecuador declared 97 percent of the Island Group a national park, with the remainder available for the resident population.

Until the 1970s, there were no more than 1,000 residents on the Galapagos. They were primarily involved in subsistence fishing activities. From 1974 to 1999, tourism contributed to an influx of immigrants from the mainland, which caused the Galapagos population to rise from approximately 3,500 to 16,184 (Ecuadorian National Census and Statistics Institute, 2000). Population on the islands increased at a rate of 7.8 percent from 1990 to 1995, with only 1.7 percent due to natural increases and 6.1 percent due to immigration from the mainland (UNESCO, 2000).

Over 80 percent of the population lives on the islands of Santa Cruz, San Cristobal, Isabela, and Santa Maria. The capital is Puerto Baquerizo Moreno on San Cristobal Island, though the largest town is Puerto Ayora on Santa Cruz Island. Largely because of tourism, these two islands have experienced the greatest population growth over the past 10 years. The Government of Ecuador, as part of the Special Law of Galapagos, limits permanent resident status to Ecuadorians who have been on the islands for five years or more. UNESCO projects the population of the Galapagos Islands to grow to 20,000 people by 2003, 40,000 people by 2015, and 80,000 people by 2027 (UNESCO, 2000).

Tourism, which has dramatically increased since the 1970s from nearly none to more than 70,000 visitors annually, is the primary source of revenue for the islands. Tourism activities include wildlife observation, scuba diving, and snorkeling. The upgrade of two airports on San Cristobal and Baltra in the 1980s allowed for the landing of larger capacity jet aircraft. Some of those living on the islands, however, still depend on subsistence fishing for food and income. These fishermen use lines and nets, and dive for lobster. The number of local subsistence fishermen in the Galapagos has increased from less than 200 in 1971 to roughly 800 in 1999 (UNESCO, 2000).

The Galapagos Islands, because of unique flora and fauna, support an active scientific research program. The CDRS is based on Santa Cruz Island and is jointly supported by the Government of Ecuador, IUCN, and UNESCO, with additional funding from a variety of European and U.S. conservation bodies and from private donors.

Cocos Island

The Government of Costa Rica took official possession of Cocos Island in 1869. After two unsuccessful attempts at colonization, the island has never sustained a permanent population. The island was declared a national park in 1978. Its only inhabitants are 10 to 15 park rangers who reside there for short periods of time (WCMC, 2000). Visitors (mainly divers) are allowed on the island for day hikes, but not for overnight stays. The nearby reefs are a popular diving destination, with an average of 1,100 visitors per year (UNESCO, 2000). Scientific research has been extensive, including studies of land birds, island flora, biogeographic affinities of insects, and the impacts caused by introduced pigs and tourism. There are no facilities for researchers other than the lodges for rangers.

Malpelo Island

Until recently, Malpelo Island, governed by Colombia, was uninhabited and seldom visited. In 1986, the Colombia Coast Guard established a station on Malpelo Island, which usually has a staff of fewer than 10 people (WCMC, 2000). No significant tourism industry exists on the island. Because of a lack of a diversified fauna and animal population, there are no known scientific research activities at Malpelo Island at this time. The endemic lizard population has been studied on various occasions since the 1970s. There are no facilities for researchers on the island.

3.2.3 South America

Although continental South America is outside the predicted impact zone of stage and fairing debris, Section 3.2.3 provides a brief overview of the affected environment between 7.4° N and 7.4° S of the equator (see Figure 3-1). The upper-stage and payload would cross this area of continental South America at an altitude of over 180 km (112 mi).

The portion of South America and Central America within the affected environment includes all of Ecuador, Surinam, and French Guiana, and portions of Colombia, Venezuela, Peru, Brazil, Guyana, and Panama. There are 29 national parks or national reserves—three of which are on the UNESCO World Heritage Site List—located within this affected environment (Hammond, 1996; UNESCO, 2001). The portion of South America within the affected environment generally consists of three geographical areas traversing from west to east: the Pacific coastal lowlands, the Andean mountain range (including high elevation valleys and plateaus), and the eastern lowlands (including much of the Amazon River Basin; see Figure 3-10). Each of these areas is described below in terms of geology, biological communities, and demographics. The proposed project would not affect other aspects of the environment—such as atmospheric conditions, aesthetics, noise, socioeconomics, and cultural resources—because the payload would cross South America at an altitude of over 180 km (112 mi), which is above the mesosphere (see discussion in Section 3.4 of the February 11, 1999 EA).

3.2.3.1. Pacific Coast and Coastal Lowlands

The Pacific coastline is generally steep and rocky, but is interspersed with sandy beaches, barrier islands, and brackish lagoons. The flat coastal lowlands variably extend 16 to 160 km (10 to 100 mi) inland from the Pacific coast to the foothills of the Andes. The northern part of these coastal lowlands in Colombia and northern Ecuador is covered by tropical rainforest, which transitions to relatively arid conditions in southern Ecuador and northern Peru (Clapperton, 1993).

These lowland forests support a diversity of animal life, including anteaters, sloths, several monkey species, tapirs, peccaries, deer, and large rodents such as agoutis, pacas, and capybaras. Large carnivores, such as pumas and jaguars, are increasingly rare.

Figure 3-10
Major Natural Vegetation Zones of South America

Source: Clapperton, 1993.

The coastal lowlands — with their hot and humid climate, dense rainforests, infertile soils, and rocky coastline — are sparsely populated. One major exception is Guayaquil, Ecuador's largest city, which has a population of over 2 million and is located at one of the few natural harbors along South America's Pacific coast.

3.2.3.2. Andean Mountain Range

Tectonic forces formed the Andean mountain range when the spreading Atlantic seafloor thrust the South American plate up and over the eastern margin of the Nazca and Caribbean plates. As is common along the margins of tectonic plates, the Andean mountain range includes numerous volcanoes and is commonly subject to earthquakes. Pre-Cretaceous metamorphic and plutonic rocks characterize the underlying geology. The Andes are among the world's youngest mountain ranges and among the highest, reaching elevations above 6,000 m (19,800 ft) (Clapperton, 1993).

Plant life in the Andean Mountains is strongly influenced by elevation and precipitation. Many species are specific to relatively narrow altitudinal bands. Alpine rain tundra forms at the highest elevations below the snow line and is dominated by lichens and bryophytes. A subalpine rain zone has three main vegetation types: tussock grassland, cushion plants and other low-growing species, and bamboo. Montane rainforest is found at lower elevations [(below approximately 3,500 m (11,500 ft)] and in the valleys. Subtropical rainforest occurs below elevations of 2,200 m (7,200 ft), with very high species diversity (Clapperton, 1993). Figs, laurels, palms, and wild avocado are common canopy trees.

The faunal species distribution in this region is related to altitudinal vegetation zones. At the highest elevations, mountain tapir, puma, guinea pig, and Andean fox are common. At lower elevations, spectacled bear, jaguar, ocelot, and various deer species are present. Over 1,500 species of birds are found in the Andean region, including toucans, hummingbirds, and songbirds (Ridgely, R.S., 1994; Altman A., 2000).

Despite their high elevations, the fertile valleys of the Andean region are the primary centers of population and economy. In this area of South America, alluvial soils found along principal river valleys and soils of volcanic origin are exceptionally productive and support agriculture, especially coffee farming. Major cities include Bogota (pop. 6.0 million), Medellin (pop. 2.0 million), and Cali (pop. 2.0 million) in Colombia and Quito in Ecuador (pop. 1.4 million).

3.2.3.3. Eastern Lowlands

The eastern lowlands form the majority of the Amazon River Basin and extend eastward from the foothills of the Andes (generally below 1,000 m or 3,300 ft) nearly to the Atlantic Ocean. This region consists of gently undulating topography in the west transitioning to relatively flat topography in the east along the Amazon River. A large freshwater sea occupied these lowlands during the Pliocene Epoch (5.3 to 1.6 million years ago). An outlet to the Atlantic was subsequently established, and the Amazon and its tributaries formed in the former seafloor (Bigarella and Ferreira, 1985).

The Amazon River drains approximately 6 million km^2 (2.3 million mi^2) and is the largest river in the world in terms of volume. Most of the rivers that drain the eastern Andes are tributaries to the Amazon, including the Putumayo, Japura, Maranon, and Negro rivers. The basin experiences high rainfall for most of the year, with precipitation averaging approximately 3,000 millimeters (mm) (119 in) annually (Salate, 1985). Around June, the Amazon overflows its banks, floods over 64,000 km^2 (25,000 mi^2) of land referred to as the varzea, and deposits nutrients that enrich the alluvial soils. The remaining portion of the Amazon basin is referred to as terra firme or upland areas.

These eastern lowlands are dominated by tropical rainforest, or selva (Pires and Prance, 1985). The Amazon rainforest is incredibly complex and has among the highest biodiversity anywhere in the world. Approximately 25 percent of the world's primary forests are located within the confines of the Amazon basin. The rainforest is composed of several layers. In the canopy, enormous trees such as the rubber tree, silk-cotton, Brazil nut, sapucaia, and sucupira reach heights in excess of 67 m (220 ft). Two or three layers of smaller shade-tolerant trees are found below the canopy, including palms, myrtles, laurels, figs, mahogany, and rosewoods. Throughout the canopy and subcanopy are many epiphytes, such as orchids and bromeliads, ferns, and mosses. A network of woody vines called lianas links the entire forest. Over 2,500 species of trees alone are found in the Amazon.

The rainforest also provides habitat for a diverse array of animal species (Junk and de Silva, 1997). Many of the mammals are arboreal and live in trees, such as monkeys and sloths. Other mammals include the tapir, the white-lipped peccary, several species of deer, and many rodents. Carnivores include jaguar, ocelot, pumas, coati, and weasels. The Amazon basin is rich in bird life, with parrots, macaws, hoatzins, woodpeckers, parakeets, many species of waterbirds, and ground-dwelling birds such as tinamous and quail (Petermann, 1997). Insects represent the largest percentage of Amazonian organisms, with more than 8,000 species classified (including mosquitoes, black flies, beetles, cicadas, spiders, and butterflies) and likely many more yet unidentified.

The Amazon and its tributaries support over 2,500 species of fish, including pirarucu, various catfish, and piranha (Junk, et al., 1997). Crocodiles, manatees, freshwater dolphins, and several aquatic mammals such as the capybara, are all found in and along the Amazon's rivers.

Most of this region is sparsely populated. The few inhabitants are generally confined to small settlements at the foot of the Andes, along the banks of the main rivers, and along the Atlantic coast. New roads extending from the Andes encourages colonization. Major cities in the rainforest include Iquitos (pop. 280,000) in Peru and Manaus (pop. 1.0 million) in Brazil. Major port cities along the Atlantic coast include Belem (pop. 1.5 million) and Macapa (pop. 89,000) in Brazil, Cayenne (pop. 38,000) in French Guiana, Paramaribo (pop. 216,000) in Surinam, and Georgetown (pop. 250,000) in Guyana.

3.3 LEGAL FRAMEWORK

The legal framework is the same as described in Section 3.6 of the February 11, 1999 EA and is incorporated by reference. (See Appendix A.)

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